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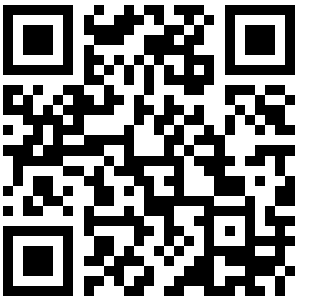

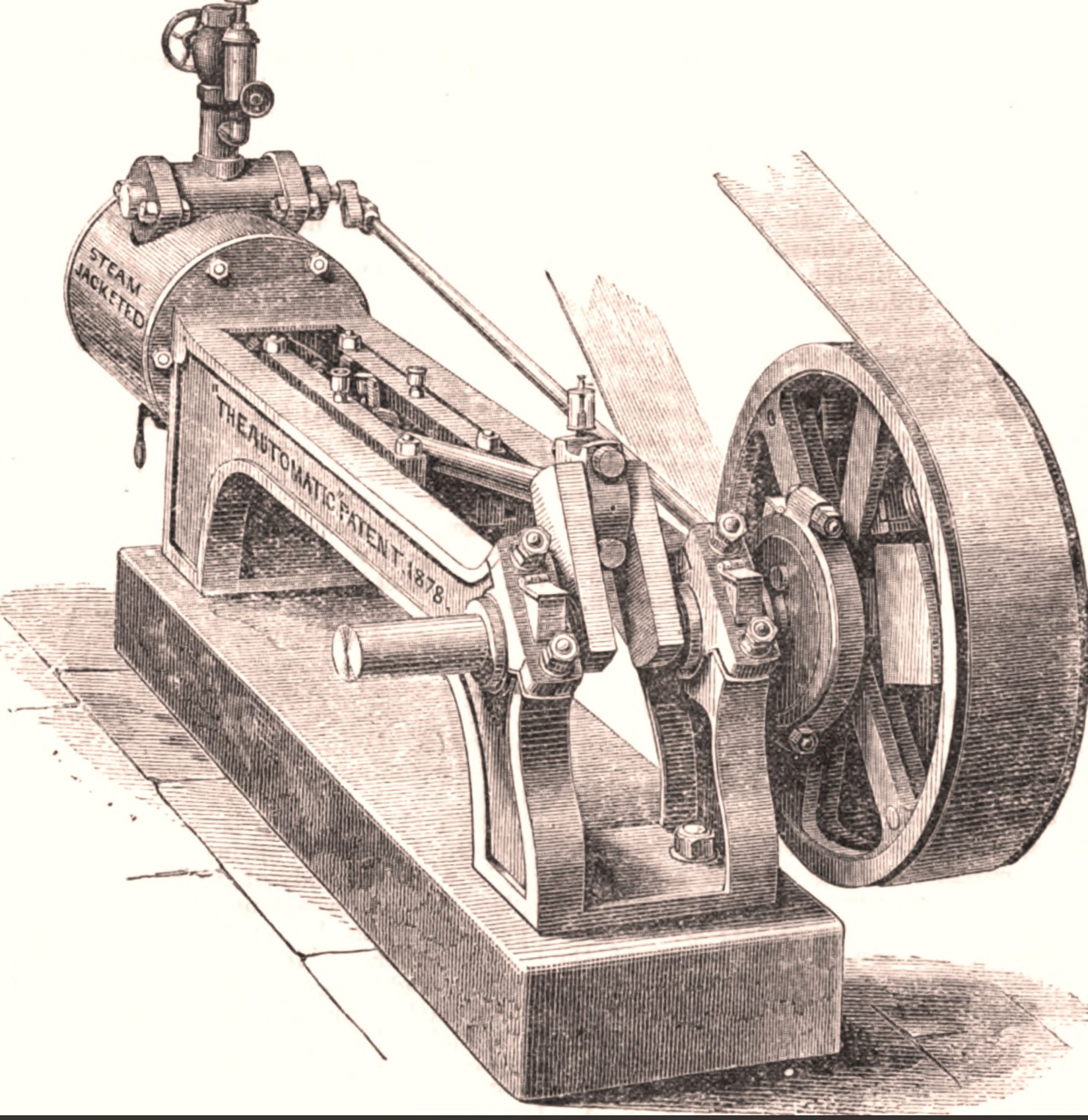

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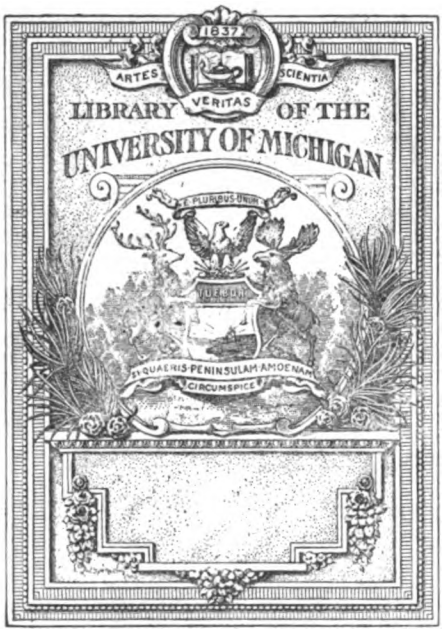

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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

No. 1.—Vol. II. SATURDAY, NOVEMBER 23, 1878. Price 4d.

NOTES.

Sun Electric Light Company.—We understand that this Company has applied its system of Electric Lighting to the machine shop at the works of Messrs. Grant and Co., Turnmill-street.

The Great Northern Company.—The Great Northern Telegraph Company announce that their cable between Nagasaki and Shanghai is repaired. Messages are, therefore, again received for all stations in China as well as Japan.

Popular Science in Germany.—A Telegraphic Museum was inaugurated at Berlin on the 1st inst. The collection is intended for the instruction of the people, and includes over two hundred objects connected with telegraphy and some historic instruments. Submarine and military telegraphy are specially well represented.

New Electric Motor.—M. Trouvé has laid before the *Société de Physique* a new electric motor, composed of a series of articulated parallelograms, similar to those of the "lazy tongs." Each lateral articulation is provided with an electro-magnet, these magnets being caused to attract or repel each other through a very small distance; whence the name of *constant force motor* given by the inventor to the apparatus. The *stroke* is proportionate to the number of parallelograms used, and may be indefinitely augmented.

Platinum Plating.—Great difficulties have been experienced in securing a platinum deposit of uniform colour and sufficiently adhesive to secure copper and other metallic vessels from the corrosive action of acids. Böttger recommends a solution of freshly-precipitated, well-washed double chloride of platinum and ammonia in a tolerably strong boiling solution of citrate of soda. By using two strong Bunsen elements with such a solution, a beautiful, brilliant adhesive coating of pure platinum may be secured.—*Dingler's Jour.*

Subdivision of the Electric Light.—In the opinion of M. Fontaine, it is impossible, in the present state of science, to *economically* subdivide the electric light. He states that, with a single light equal to 500 standard gas burners, the advantage of economy is on the side of the electric agency, even if only one quarter of the light produced is actually utilised. If the light be reduced to 50 burners, the advantage is still on the side of electricity; but, if it be diminished to 20 burners, there is equilibrium between gas and electricity in the matter of cost; whilst, if we take an electric light equal to only 10 burners, the illumination is less cheaply produced than it would be with gas. It should be remembered, moreover, that the gas supplied in Paris is twice as dear as and much inferior to that supplied in London.

The Phoneidoscope.—Mr. Sedley Taylor has laid before the *Société de Physique* an instrument under this name, which is intended to represent optically the most delicate details of sonorous vibratory movement. A film of some liquid containing glycerine is produced over an aperture in a screen of blackened brass. This film reflects the light of a lamp, producing the well-known phenomena of interference, either directly upon the retina, or by means of an image projected upon a screen through a lens. So long as the film remains motionless, the various colours exhibited by such films are alone seen; but, if the vibrations of a sustained vocal sound are, by means of a large bent tube, communicated to the film, this will exhibit a geometrical distribution of colours, with fixed bands and spiral movements, the arrangement of which varies with the sharpness of the sounds produced and with the nature of the harmonics with which they are accompanied, that is to say, with their *timbre*.

Spectroscopic Temperatures.—A. Crova has measured the calorific intensity of different portions of spectra, by means of a thermo-electric pile and a very sensitive galvanometer. Representing by 1,000 the calorific intensity which corresponds to a red ray with a wave-length of 676 millionths of a millimetre, he gives the following table:—

Wave-lengths	676	605	560	523	486	459
Sun-light	1000	820	760	670	540	460
Electric-light	1000	707	597	506	307	228
Drummond-light	1000	573	490	299	168	73
Standard lamp	1000	442	296	166	80	27

The electric-light was derived from 60 large Bunsen elements,

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with Carré's carbons, in the focus of a concave metallic mirror; the standard lamp was filled with colza oil. Crova concludes that temperatures can be rigidly determined by the spectrometric method, as soon as we have ascertained the exact law of emission for all the rays and the numerical constants for each wave-length. He presents these results as a first essay towards the solution of this important question.—*Comptes Rendus.*

Transmission of Minute Sound-Waves by the Telephone.—In the course of some experiments on a telephone line, with a view to decrease the crackling due to atmospheric disturbance, an observation was made by Prof. Frazer, which will serve to illustrate to what an infinitesimal motion the sounds heard through the telephone are sometimes due. A telephone was selected, in which the diaphragm was held fast along a circular rim, instead of the flat surface, which usually binds the outside of metal plate. It was found to resound to one note (middle A of piano). On sounding this note clearly into the mouth-piece, while keeping the other telephones covered, so as not to be directly affected by the air-waves, it was found that the overtones, so very manifest in the vibrations of such metal discs, were distinctly traceable in the other telephones, with which connection was had over a line of about one-third of a mile, with a ground return-circuit. It is difficult to understand that the minute waves into which a metal plate is thrown by a vigorous note of the voice can reproduce sound, through the intermediate agency of maxima and minima of conductivity, in the medium of current transmission; but that the minute wavelets which are produced upon the backs of these should each result in fluctuations of conductivity of sufficient power to impress themselves as sounds at the extremity of a long line could scarcely have been foreseen. The experiment was only tried with the telephones in the same room, and has not yet been verified by distinguishing the overtones in the more remote instruments.

Note on Two New Forms of Bell Telephone. By Brown Ayres, B.S.—The writer some time since constructed a form of telephone belonging to the third class of magneto-telephones, according to his classification in a former number (vol. i., p. 75), a description of which may be of interest as illustrating how very little, mechanically speaking, is essential to the transmission of articulate speech. The instrument referred to consisted of a ferrotype plate, to the centre of which was connected a spiral steel spring, whose axis was at right angles to the plate, and the farther end of which was connected to an adjusting screw by means of which the tension on the spring could be varied. This spring was of a fine piano-forte wire, and was permanently magnetized by rubbing with a bar-magnet. The spring and plate were in metallic connection, so that a complete circuit could be formed through the plate, spring, adjusting-screw and outside connections. On placing in the circuit a Bell Telephone of the modified form described in the paper before referred to, and speaking against the ferrotype membrane of our new telephone, words could be distinguished in the Bell Telephone, though they were not very loud. I have thought that under favourable circumstances this instrument could be used as a receiver, motion being imparted to the ferrotype plate by the mutual attractions of the superposed portions of the helix when traversed by a current. In this event, however, the tone reproduced would be constantly one octave above the original tone as both of the alternating currents would produce attractions, the retrograde motion of the plate arising from its own elasticity and that of the helix. I have not yet applied it, however, as a receiver. The same ends would be accomplished, of course, by the use of a spring of any conducting material which was traversed by a continuous current, the solenoid then playing the part of magnet and conductor. Another form of the third class would be one in which we made the ferrotype plate a portion of our circuit, the connections being made at the extremities of a diameter, and a horse-shoe magnet being symmetrically placed with reference to this diameter in a plane through the centre at right angles to it. In both these cases we have the simultaneous relative motion of magnet and conductor, and the form first described is interesting from the fact that the helical spring is at once the magnet and conductor.—Baltimore, Oct. 19, 1878.—*Jnl. Frank. Inst.*

Influence of Temperature on the Electric Conductivity of Liquids.—The object of the investigation is to ascertain the influence of temperature on the conductivity of liquids over as wide a range as possible, extending even beyond their normal boiling points. This paper contains results which have been obtained for water, both pure and acidified, with sulphuric acid. No absolute determinations of resistance, however, have been made as yet, but only the relative determinations for the same liquid at various temperatures. In conducting the experiments the temperature of the liquid was gradually raised from that of the room, the change in its resistance being meanwhile tested, and the liquid was then allowed to cool gradually, while the resistance was again observed at different points. In some cases curves are given exhibiting the results obtained. In the first four series the water was pure, and not raised above the boiling points. There was a considerable diminution in the resistance as the temperature rose, that at 20° being about three times that of 99°. This diminution was regular until the temperature reached about 75°, when it became more sudden. This arose, no doubt, from the water at that temperature attacking the glass of the vessel in which it was contained, as, on cooling to the temperature of the room, the resistance was found to be permanently lowered. In series 5—7 the resistance was observed at temperatures above the normal boiling point, the liquid being contained in closed glass tubes. The same general decrease in the resistance was observed, with the same sudden change about 75°. In series 8—11 a drop of 10 per cent. sulphuric acid was added to 30c.c. of water. A minimum in the resistance was now observed about 80—90°, after which it rose again. In series 12 and 13 more acid was added, when the decrease in the resistance once more became regular as the temperature increased. The following appears to be the explanation of this anomalous behaviour of a weak solution of acid. The acidulated water attacks glass more readily that pure water, and sodium sulphate is formed. As there is very little acid present, the part neutralised to form sodium sulphate is a considerable part of the whole; but the addition of a very small quantity of acid will very much decrease the resistance, and conversely its removal will increase the resistance. The resistance of the water is therefore more increased by the combination of acid with the glass than it is decreased by the rise of temperature, and there is a minimum value of the resistance at the temperature where the glass begins to be attacked. When there is more acid present, that neutralised by the glass is so small a fraction of the whole that the conductivity of the liquid is not sensibly affected by the neutralisation.—*Chemical Society's Journal.*

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EDISON'S TELEPHONIC AND ACOUSTIC RESEARCHES.

The most important advance that has been made in the application of the telephone to business, manufactures, and medical science, dates from the discovery of the varying electrical resistance of certain bodies when submitted to pressure. The carbon telephone is based on this fact, and more recent discoveries prove that any mass of metal that is not continuous, like a heap of shot, a coil of chain, or charcoal impregnated with iron, will produce changes in an electrical current when submitted to pressure. This pressure may be the impact of sonorous waves of all kinds, and thus such a mass of metal may become the transmitter of a telephonic current.

The carbon telephone is only one of many contrivances for reproducing articulate speech at a distance, but, owing to its clear and truthful articulation, its simplicity of construction, and the far greater volume of sound which it creates, it is likely to be the most extensively used. Other instruments of Mr. Edison's invention, however, are not far behind it, and may by improvement be made equally effective. As a rule, Mr. Edison has succeeded better with those telephones which produce a variation in the resistance of the circuit than with such as depend for their action upon a variation of the electro-motive force or static charge.

An instrument very similar to the carbon-transmitting telephone is shown in Figure 1 (devised November 19, 1877), the essential difference being that the carbon is replaced by bibulous paper moistened with water. This semi-conductor, like the carbon, changes its resistance under the influence of varying

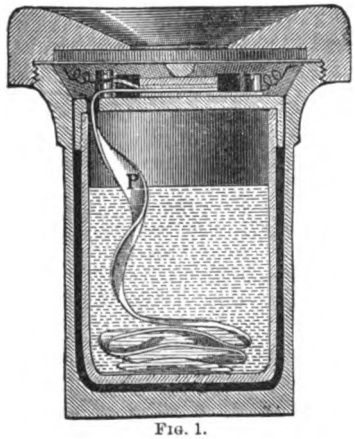

Fig. 1.

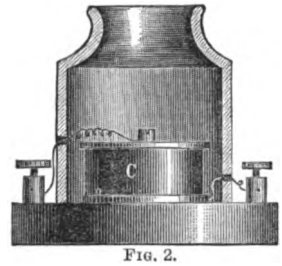

Fig. 2.

pressure. The paper is kept moist by capillary action, a strip being used, one end of which dips into a reservoir of water. In Figure 2 (devised June 27, 1877) is shown a form of the carbon-transmitting telephone, requiring no adjustment whatever, and which operates well, notwithstanding the simplicity of its construction. It consists essentially of a plate of metal resting on the bottom of a hollow vessel, and carrying a block of prepared carbon, upon which a second and light metallic plate is laid. The weight of the upper plate affords an initial pressure, which is varied by speaking into the mouth of the vessel. The carbon block may be replaced by a disc of cloth, the pores of which have been filled with pulverized blacklead. By this treatment the cloth becomes slightly conductive. The instrument thus modified is shown in Figure 3 (devised September 20, 1877). In Figure 4 (devised August 12, 1877) the pulverised plumbago, P, is floated upon mercury, M, and is compressed between the surface of the mercury and a metallic block fastened to the centre of the diaphragm.

Fig. 3.

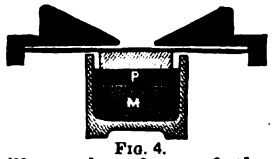

Fig. 4.

Still another form of the Edison transmitter is shown in Figure 5 (devised July 5, 1877). The carbon, C, rests upon the diaphragm, which in this instrument is a horizontal plate forming the top of a vocalising chamber, the mouthpiece being at the side. Three fine cords attach the carbon to the framework of the diaphragm, and prevent it from being displaced when the diaphragm is vibrating. In appearance this instrument resembles the Reiss telephone, and in principle it would be much the same were it not that, in vibrating, the carbon never actually leaves the plate upon which it rests, but simply for an instant releases its pressure. It is evident that the resistance of the circuit depends upon the electric connection between the carbon and the diaphragm, and that this connection depends upon the pressure of the carbon, which is constantly changing when the diaphragm is in vibration. This apparatus is too sensitive to extraneous sounds to be useful in telephony.

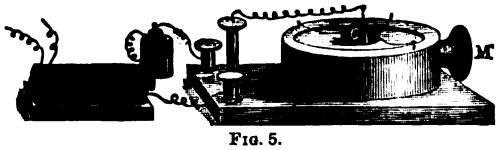

Fig. 5.

Another form, acting on much the same principle, is illustrated by Figure 6 (devised Sept. 30, 1877); it is called the "Inertia Telephone," though it is hardly certain that its action is to be attributed solely to inertia. The carbon, C, is placed between two metallic plates, one of which is fastened to the diaphragm, and the other is held by a screw bearing in a framework attached to the diaphragm by insulating supports. When vibrating, the whole system moved, instead of the plate P alone, as in the ordinary carbon transmitter. Mr. Edison's explanation of its mode of action is, that the degree of pressure with which the carbon rests against the plates is varied during the vibration. Thus, after a movement toward the right, the diaphragm suddenly stops, and the carbon pressed in virtue of its inertia on the plate P.

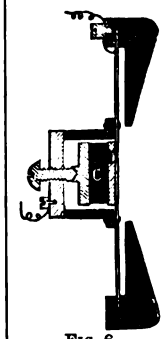

Fig. 6.

An advantage which the magneto-telephone had over the earlier forms of Mr. Edison's telephone is, that its diaphragm does not touch anything, and can, therefore, vibrate with perfect freedom. On the other hand, the diaphragm of the carbon telephone, used before his adoption of the present non-vibrating rigid plate, pressed with considerable force upon the carbon, and thus caused it to make false vibration.

In the form shown in figure 7 (devised June 25, 1877) this difficulty is not encountered. The diaphragm carries an armature A of soft iron, which confronts but does not touch the magnet B. A and B are opposite poles of the same magnet, being connected at P, and polarized by a local circuit. The magnet B presses upon the carbon at C, the pressure being regulated by the screw S. The attraction between A and B varies with the distance between them. When, in vibrating, A moves toward B, the attraction rapidly increases, and B lessens its pressure upon C. During a motion in the opposite direction the attraction diminishes, and B, drawn by the spring S, increases its pressure upon C.

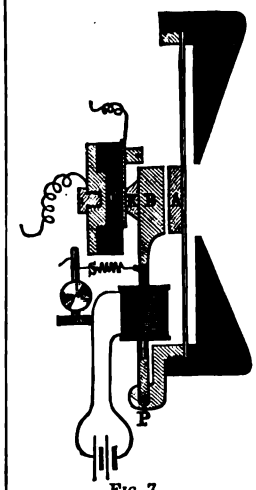

Fig. 7.

A similar contrivance is illustrated in figure 8 (devised April 10, 1877). The diaphragm carries an armature A, which by its motion changes the potential of two electro-magnets. These changes in magnetism cause a bar, situated in their magnetic field, to reproduce the original vibrations. The ends of the bar are held by the magnetic force against two pieces of carbon, *c* and *c*. These and the bar are included in the primary circuit of an induction coil. The resistance of the circuit decreases when the bar is drawn up, and increases as the bar descends.

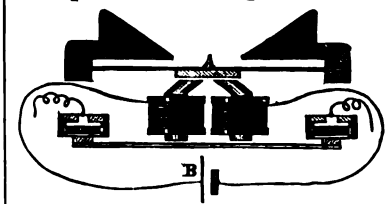

Fig. 8.

Of all substances which have thus been tested in the telephone for increasing and decreasing the resistance of the circuit by the effect of the sonorous vibrations, lampblack from the lighter hydrocarbons proved the best. It is very essential that the lampblack should be deposited at the lowest temperature possible, and the flame of the lamp should not be allowed to play upon the deposit, otherwise the product is of high resistance, and wholly unsuitable for this purpose. Commercial lampblack of the best quality scarcely allows a current to pass through it, while that obtained by the process herein described offers but slight resistance.

The lampblack as it comes from the burning apparatus is laid upon a white slab, and those portions which have a brown tinge are picked from the mass; the remainder is then ground in a mortar, and placed in a large mould, and subjected to a pressure of several thousand pounds. The cake thus pressed is repowdered and re-pressed several times. Finally, it is weighed out in divisions of 300 milligrammes, and moulded into buttons, as seen in the telephone.

The reason why lampblack thus moulded is superior to any

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other material is satisfactorily explained when we consider that, of all finely divided substances obtained, either by mechanical action or chemical precipitation, it is seen, when under the microscope, to have the greatest number of particles, or, in other words, to be the most finely divided. Now, it is well known that the increase and decrease of the resistance of any button of finely divided conducting matter, when subject to pressure, is due entirely to the contact of a greater or less number of particles at the junction or surfaces.

Again, it is known that the telephone is exquisitely sensitive to the slightest change of resistance in the circuit; hence, if a button of gas-retort carbon composed of inelastic particles few in number (as compared to lampblack) is used in a telephone, the production of a wave by gradually increasing pressure is obtained by the gradually increasing number of particles which are brought in contact with the surface plates. Now, these particles are so few and large, and, in many cases, several particles aggregated in the retort carbon, that the wave, instead of being pure, is harsh and grating. This wave may be graphically represented by a serrated line inclined at an angle of 45°, the points representing the disturbance of the current by the effect of the particles themselves. Now, if the button of gas-retort carbon be replaced by one of graphite, which is composed of much smaller particles, with no aggregations as with the first, the waves will be represented by the line as above, but the points will be scarcely perceptible, and these gaps being so minute are beyond the power of the telephone to detect; hence we obtain a pure wave; but these gaps weaken the wave, as a whole, by their effect on the self induction of the telephone receiver. But, in the case of lampblack, the particles are infinitely finer than graphite, and, moreover, the button is somewhat elastic; hence the line representing the form of the wave will be perfectly straight, although, theoretically, there are gaps. They are infinitely small as compared to graphite or other conducting material; therefore we not only prevent harsh sounds, but obtain a stronger wave, owing to the absence of gaps and their effect on the self-induction of the magnet. Lampblack, when moulded into buttons, possesses another property, differing from all other conducting material, and that is its elasticity. For instance, if we subject buttons of different materials to pressure, the greatest difference of resistance with a given weight will be produced on the lampblack button; again, if we increase the weight on all the buttons, a point will be reached where any additional weight ceases to reduce the resistance appreciably, except in the case of the lampblack, which continues to show decrease of resistance by additional weight placed upon it, long after the other buttons cease to be affected, as all the particles that can come in contact will be brought in contact by a slight weight, owing to the inelastic nature. Mr. Edison has endeavoured to obtain an approximation as to the number of points of contact on the lampblack button now used. In order to accomplish this purpose he first placed a Rutherford diffraction grating under the microscope, having 17·291 lines ruled on speculum metal within a space of one inch, and by the side of this a button of lampblack, then by changing from one to the other he calculated that there were not less than ten millions of points upon the surface of the button, nearly all of which were constantly in use when subjected to the sonorous vibrations. Had the Rutherford grating been ruled both ways, there would have been 298 millions of points, and there is little doubt that a button of platina ruled double in this manner would give good results in the telephone, but would not equal the lampblack, owing to its want of elasticity.

The elasticity of the lampblack button has another advantage, insomuch that it allows a considerable initial pressure to be placed upon it without materially reducing its sensibility; hence the apparatus is not so liable to be thrown out of adjustment as those employing an inelastic button, where the initial pressure must be exceedingly light to retain its sensibility. When adjusted in this manner, a loud sound caused a break in the circuit, and the sounds are harsh and disagreeable, and allow sparks to occur which in time coats the metallic armature, and renders it unfit for use. The only defect, if so it may be called, in the button made of lamp black is that it is somewhat friable; but Mr. Edison's experience goes to prove that, if the telephone is made in a proper manner, so that no part of it will, when under the effect of the sonorous waves, vibrate and hammer the button, it will last for months, and, as far as can be seen, will continue to last as long as the instrument that holds it; but, if the instrument is so devised that the armatures are allowed to hammer the button, or, if the initial pressure is very light, and the instrument receives a violent concussion (for instance, by being dropped on the floor), the button is liable to crack; but, even in this case, the volume of sound is not materially lessened. Mr. Edison has attempted to harden these buttons by mixing the lampblack with sugar, tar, and other substances, previous to moulding, and after moulding subjecting them to a high temperature. This treatment makes them hard, but inelastic, and yet far superior to any other substance which he has tried.

The value of different substances to be used as buttons in the telephone are given below, the first-mentioned being the best, and the others in the order given:—

Lampblack. Iodide of copper. Gas carbon.
Hyperoxide of lead. Graphite. Platinum black.

Finely-divided materials which do not oxidise in the air, such as osmium, ruthenium, silicon, boron, iridium, and platinum, give results proportionate to this minute division, but many of them are such good conductors that it is necessary to mix some very fine non-conducting material with them before moulding. All the conducting oxides, sulphides, iodides, and nearly every metal finely divided, has been tried by Mr. Edison in various states of divisibility, and mixed with various substances. Liquids in porous buttons of finely-divided non-conducting material render these particles conducting, and they consequently act in the same manner; but, of course, owing to the formation of gas, polarisation, &c., they are objectionable.

THE MICROPHONE.

The device of using several pieces of the semi-conductor instead of one was early tried by Mr. Edison. He found, in general, that the loudness of the sound was increased by thus multiplying the number of contact surfaces, but also that the articulation was impaired. Instruments of this nature have since become known as microphones, though it is not probable that faint sounds were ever augmented through their agency so that they could be easily recognised at a distance from their source. Figure 9 shows one of the first forms invented by Mr. Edison, April 1, 1877. Four pieces of charcoal are used, C C, &c., each supported by an upright spring, as at S and S'. The piece of charcoal nearest the diaphragm impinges upon a disc of carbon, which is fastened to the centre of the diaphragm. The primary wires of an induction coil are attached to the diaphragm and the spring S. The circuit is then completed through the semi-conductors.

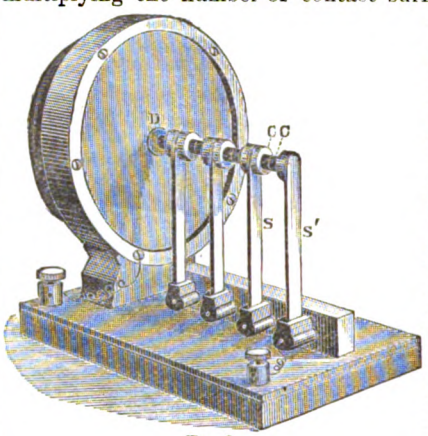

Fig. 9.

Other forms are shown in figures 10 and 11. The former has two carbons separated by a plate of metal. The latter has three contiguous pieces of carbon.

Figure 12 (devised Sept. 21, 1877) illustrates a microphone,

Fig. 10.

Fig. 11.

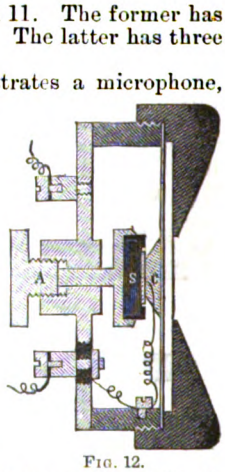

Fig. 12.

having ten plates of zinc, a mixture of dextrine and lampblack having been previously worked into the pores.

In Figure 13 (devised June 7, 1877) fifty discs, D, with iron protoxidized on the surface, are shown enclosed in a glass tube.

A novel form of transmitter, used by Mr. Edison in his experiments is shown in Figure 14 (devised Aug. 12, 1877). The semi-conductor is a collection of small fragments of cork covered with plumbago. It can be used with or without a diaphragm. The instrument shown in Figure 15 (devised August 24, 1877) acts both as a transmitter and receiver, the latter fact being discovered by Mr. Charles Batchelor, Mr. Edison's assistant. The solid carbon of the transmitter is here replaced by silk fibres coated with graphite. Its action as a receiver is probably due to the attraction of parallel currents, the volume of

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the whole being contracted during the passage of a current through F.

In the accounts which have been published of experiments with the microphone the statement has frequently been made

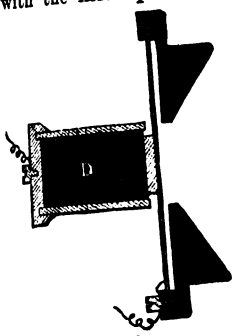

FIG. 13.

FIG. 14.

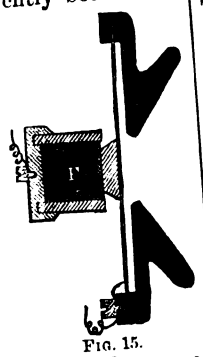

FIG. 15.

that minute sounds are actually magnified by it, in the same sense that minute objects are magnified by the microscope. A little reflection will show, however, that there is no real analogy in the action of the two instruments. The sound that is heard in the receiving instrument of the microphone when a fly is walking across the board on which the transmitter is placed is not the sound of the fly's footsteps, any more than the stroke of a powerful electric bell, or sounder, is the magnified sound of the operator's fingers tapping lightly and, it may be, inaudibly upon the key. This view of the subject readily explains why the microphone has failed to realise the expectations of many persons who, upon its first exhibition, enthusiastically announced that, by its aid, we should be able to hear many sounds in nature which had hitherto remained wholly inaudible.

(TO BE CONTINUED.)

THE SOURCE OF SOUND IN THE TELEPHONE.

Professor D. E. Hughes has recently published the results of a series of experiments which he has made on this subject. At the outset, he believed that molecular action played an important part, but his investigation led him to believe that it bears no comparison with electro-magnetic attractions and repulsions. For these experiments three Daniell's cells were employed, and each part of the microphone carefully examined, but no sounds were heard that could be fairly attributed to molecular action, whilst the effects due to known electro-magnetic action were extremely marked and distinct. The Professor used vertical microphones, and arranged them in two distinct circuits; the first being used as a transmitter of undulatory currents to the telephone coil under investigation, the second was attached to a small square board (6-in. side), insulated by india rubber. From the latter, wires were led through a battery to a telephone. The source of sound at the distant microphone was generally an ordinary French *reveil* clock, as this gave the maximum of sound obtainable without interruptions in the circuit. The microphone was so adjusted that it was only sensible to sounds mechanically transmitted to it through the board, and was insensible to sonorous waves transmitted through the atmosphere, so that each organ of the telephone could be investigated separately by putting that piece alone in contact with the microphone table, keeping the other organs at a distance in the air. The apparatus then consisted of a transmitting circuit, dissecting table and microphone, and the receiving circuit. The transmitting circuit consisted of the vertical microphone on its sound table, the clock or source of sound, three Daniell's cells, one pole of which was connected to one pole of the microphone, the other pole was connected through the "organ" under experiment to the other pole of the microphone. The dissecting apparatus, which we will call D, consisted of a microphone and its table. On this table, the "organ" under examination was placed, connected as above described. The two poles of the microphone D were the one through a telephone to one pole of these cells, the other to the other pole of the battery. The first experiments were with the coils of telephones, the coils being placed on the table of the dissecting microphone. The investigations and the results are best described in the words of Professor Hughes:—

COILS.—Experiment I. The ordinary coil of a telephone being placed on the table gave out no appreciable sounds. (I may here remark that, when I say no sounds, I merely state that with the feeble undulatory currents employed no sounds were heard, although this same current was sufficient to produce exceedingly loud tones when all the organs of the telephone were put together and properly adjusted.) In the above case feeble sounds were heard if the battery was increased to twenty elements. Different coils of size, shape, and number of wire were tried, but no sounds were audible on any. On now approaching a strong bar magnet (6 × 1 inch) near to the coil, say ¼ inch distant, I at once hear the sound with all its peculiar timbre, the sounds increasing or decreasing as I put the magnet nearer or farther from the coil. The sounds, however, at their maximum, were but one-fortieth (approximately) of ordinary telephonic ones.

It is here evident that the sound is due to the mutual action between the current in the coil and the strong magnetic field, in other words, to that electro-magnetic action which tends to cause a current in a wire crossing the lines of force in a magnetic field to move in a direction perpendicular to itself and to the lines of force which it crosses.

II. A coil of fine iron (covered) wire (No. 30) gave out at first no sounds, but gradually became audible as the wire itself became magnetised by the current. If the bar magnet was brought near, the sounds were much louder than the copper coil, being about one-thirtieth of telephonic ones. The magnetic field is here increased by the wire itself being a magnet.

III. Two coils of copper wire of similar length but of different shape, the one being two inches in height by one inch diameter, the other a flat coil of two inches diameter by half an inch; each being tried separately, it was found when the pole of the magnet was held near their centres that the flat coil gave out double the sound of the other, but, if held near the sides, the reverse effects took place.

(The larger surface of the flat coil explains the increased sound when a magnet is held over its centre, but in the second case the longer surface of the two-inch helix explains its increased action).

IV. The coil resting upon the table giving out clear sounds when the magnet was near, the magnet was replaced by the coil of an electro-magnet without its iron core. With a strong local battery passing through this coil similar effects to those of the magnet were obtained, though not so strong, owing to the difficulty of inducing so strong a magnetic field as the magnet alone; but on introducing its iron core the sounds became as loud or louder in proportion to the strength of the field of force.

V. If a flat magnet was laid on the table and the coil held at a distance, the sounds were louder and more metallic than in the cases when the coils were placed on the table. If the magnet was inside the coil and also resting on the table, the sounds were not nearly so loud as when the coil rested simply beside the magnet.

(In this case, if the coil was absolutely fixed upon the magnet, and no movement possible of the copper wire, we should only have the sounds due to the magnet and coil reacting upon the earth's magnetic field, and I found that if the coil was loose, much louder sounds were obtained than when it was fixed; but when it was placed flat on the side of the magnet, the full electro-magnetic reactions of coil on magnet were observed, consequently the sounds proved to be much louder than when the magnet was placed in the centre of the coil.)

VI. If instead of the bar magnet both poles of a horse-shoe magnet were introduced, the sounds were still heard, but far more marked when the coil lies on the sides of the horse-shoe. In this experiment the north and south pole, both being in the same coil, it would be natural to believe that one should neutralise the effect of the other, and I originally held this to be an argument in favour of the molecular theory; but we shall see in experiments under the head of "pendulum," that it is fully explained by the greater effect of the magnetic attractions than the repulsions.

VII. If on one end of the bar magnet with its coil a microphone was attached, so as to be influenced only by its elongation, no sounds whatever were heard—although it was sensitive to a hair lightly drawn across the pole. No trace of sound whatever could be heard; thus, if the sound was due to molecular changes, we should have certainly expected to have heard slight sounds, at least, from an undulatory current, which was producing sufficient electro-magnetic changes to give out the loud tones upon the diaphragm, as already mentioned.

VIII. If upon the microphone table I strained a wire six inches long, similar to a musical string, and through this wire pass the current, I heard no sounds; but on putting a strong horse-shoe magnet so that the wire was between the poles (which in this case should not be apart more than ½ inch), I heard very plainly, and remarkably so, when we consider that in the case above mentioned, there were but a few inches of the wire under the influence of the magnetic field. Sounds were thus obtained from a wire only one centimetre long on the board; fine iron wire gave out the loudest effect, but this was found to be due simply to its becoming magnetised, and thus reacting more strongly on the field of force.

(In all the above experiments the sound obtained was not at its maximum more than one-twentieth of telephonic ones, so we cannot consider any of these points as predominant sources of sound.)

(TO BE CONTINUED.)

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

TITLE PAGE AND INDEX.

The Title Page and Index for our First Volume, which was completed by the last number, is issued as a Supplement with the present number.

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ELECTRICIANS AND THEIR EMPLOYERS.

From several different quarters during the past year this country has been reproached for its backwardness in the field of telegraphic discovery, and various explanations have been suggested to account for what nobody seems prepared to deny. One authority charges it to the paralysing effects of monopolies; another lays the blame on our inferior workmen; whilst Mr Edison, speaking for America, ascribes her superiority to facilities afforded to experimentalists. We shall have more to say on this point further on; but, speaking broadly, the reason appears to us to lie more on the surface, and is not far to seek. It is as true of nations as of individuals, that what they originate themselves they are slow to improve. They stick to their own, partly because it is their own, partly from the practical consideration that, having got a serviceable article, its displacement, even by a better, would be expensive. England stands foremost amongst originating nations, but the people who borrow at second hand are they who can best afford to spend their ingenuity on developing and perfecting. Again, in a country like ours, there is a limit to extensions which, in most directions, has practically long ago been reached; and, possessing a large stock of material and appliances, the companies may be excused if they regard with little enthusiasm any line of investigation that may disturb existing state of things. It is easy to suggest improvements, and, in undeveloped countries, it is easy to adopt them. For England, however, and the systems radiating from it, the inventor has to demonstrate something more than his own ingenuity; and this something is a factor which inventors, as a rule, never take into their reckoning.

While, however, freely making these allowances, called for by the peculiar circumstances of the country, we are distinctly of opinion that timidity and conservatism have been carried too far; and we regard with satisfaction those recent events which must soon bring it home to our British telegraphs, both submarine and inland, that their interests, as well as their prestige, are threatened. Electrical science is taking a new departure; fresh light crowds in upon us from all quarters; and it will no longer *pay* to rest and be satisfied. The time, too, is not inopportune; displacement of old stock has become more and more necessary every day; extensions do take place, though not on a large scale; and traffic assuredly increases, though gradually. Improvements taking the shape of modifications, adaptation, and in some cases rejection, might now, therefore, be conveniently introduced without involving wholesale change and disruption. But the tendency of late years has been to let things "slide," and to eliminate everything suggestive of novelty. Those eminent men who found their fullest energies employed in developing our telegraph system have had to find spheres of action elsewhere; and, with the exception of innovations like the Wheatstone Automatic and the Duplex, whose claims were irresistible, that system remains pretty much what it was when the projectors left it. Since then the public companies, under which designation we include the Government telegraphs, have been dependent upon and at the mercy of outsiders over whose productions only a very imperfect supervision can be exercised. The wonder is that material and appliances continue as excellent as they really are; but that these outsiders are deficient in expedients for the adaptation of old means to new ends can surprise nobody, seeing that the persons most concerned have no voice in the matter. We cannot illustrate our meaning by recent examples, because to do so would be invidious; but a casual glance at the instruments of a past epoch still surviving will bring to light the apathy, the dulness, or the helplessness—we don't know which to call it—that has so long prevailed. Would the Bell instrument, for example, be what it still is if the convenience of the operator had been considered? Yet the Bell instrument, with its differently toned bells, which are useless, and their resonance, which is a nuisance, is still turned out with all its pristine, theoretical beauties "thick upon it," to be muzzled and choked by the operator directly he gets it to himself. Again, the maker of the Morse instrument did not have to transcribe "slip" the day long, or, we may be sure, he would have placed it lower down and at a different angle. It took a dozen years to get rid of the blinding embosser, and at this rate it will take as many more to supersede—surely, not an impossible feat—the objectionable and unreliable inkwell. Redundancies too, which mean extravagances, are to be seen everywhere, notably in the Single Needle, a comparatively inexpensive instrument, but one which, we are told, is made in enormous numbers for use in this country. That the

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venerable "Double Needle," which was a "show" instrument in its day, confronted us like a Doric temple of superfluous mahogany was excusable; but in these days space and economy are of first importance, and we venture to assert that they are not studied as they ought to be. The Single Needle is also conspicuously inconvenient. The dial, the writing desk, and the handle are at different levels, an arrangement which necessarily results in slow reading—a fault from which the Mirror instrument is not entirely free. As regards the "Sounder," simple as it is, it is far from being perfect either in the character of the sounds, those of beat and recoil, or the adjustments. If it were anybody's business to consider the initial difficulties of learning to read by sound, insurmountable even in the case of some skilled operators, we should soon find a more exact way of indicating the duration of a beat than by an interval of absolute silence.

When we turn to purely technical matters, the same apparent lack of originality and enterprise presents itself, though we cannot be specific without seeming impertinent. The illustrations we have selected relate to the workshop; and, after all, the electrician's shortcomings are traceable to that source mainly. He has ideas, but nobody is at hand to work them out. If he seeks assistance he has to find it outside, and we have just been told what that means. Professor Bell's stay in England has inflicted upon him a plethora of ideas for want of intelligent workmen to carry them out. The British mechanic, says Professor Bell, will work only in a groove; and the mechanic himself retorts that his master won't let him work otherwise. Now, these are the people on whom our public telegraph companies and their professional servants are content to rely. What we would have them do is to trust to themselves, at all events for testing their own conceptions, and for the initial manufacture of a best article. That there is no lack of knowledge and originality in the superior officers, we are sure of; and the telegraph service is especially fruitful in the production of ingenious and skilful persons who can turn their hands to anything, and who possess besides a sufficient, though, perhaps, not a profound acquaintance, with the technical mysteries of their calling. They are to be found almost everywhere, from Newfoundland to Kurrachee, in the solitary cable hut as well as at head-quarters. These are the material to be cherished and utilised by the professional electrician. The small outlay necessary for fitting up a mechanician's workshop and a not over-pretentious laboratory would repay itself tenfold in improved apparatus, greater purity of articles purchased from manufacturers, a more scientific supervision of cables and land-wires, more efficient contrivances for overcoming defective working, a higher reputation, and increase of traffic.

We should expect these obvious facts to have been recognised by the Government Telegraph Administration long ago; but, whilst our naval and our military departments have ample provision for independent investigation, and for examining what is submitted to them from without, we can discover nothing of the kind attached to the national telegraphs. Such a scandal as that we commented upon a few weeks ago in relation to Mr. Herring's invention would have been impossible if there had existed any establishment commanding the inventor's respect to test and, if necessary, condemn his suggestion at once. Not so long ago a high official of the Postal Telegraphs publicly admitted that we in this country looked upon the approach of an inventor with horror. The horror, it seems to us, ought to be all on the other side of the door. If it were known that perfect means of demonstrating the inutility of a suggestion really existed inside, none but the very good thing would ever venture that far. All alike ought to have fair play; a public department owes this much at least to outsiders, and to a very considerable extent it would soon be independent of them.

What we desiderate is that the companies should enable their professional advisers to at least keep pace with the times. Independent electricians can afford to do so, or they may, without loss of reputation, follow the bent of a specialty all their own. Not so the working telegraph engineer; and, although the employers have a right to demand all that we have suggested, it is plainly their duty and their interest to provide the means.

CORRESPONDENCE.

ELECTRIC LIGHT FORMULÆ.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In my last letter on this subject I inadvertently did an injustice to the dynamo-electric machine of M. Gramme. In the equation H.P. = h.p. × 2·63, h.p. is the horse-power utilised in the arc itself under certain given conditions. But, if h.p. be taken to express the total horse-power converted into electrical work (in the whole circuit), then we have, under the best conditions, with a Gramme machine of the form experimented with at the Franklin Institute,

$$\text{H.P.} = \text{h.p.} \times 1{\cdot}39,$$

and the efficiency of the machine is expressed by

$$\frac{\text{h.p.}}{\text{H.P.}} = {\cdot}72 \text{ (nearly)}.$$

Or the machine can convert into electrical work 72 per cent. of the energy expended upon it.

Perhaps you will allow me to revise and extend the formulæ as follows:—

Let E = the electromotive force, in Volts, acting in a circuit;
R = the total resistance, in Ohms, of the circuit;
r = resistance of the voltaic arc obtained;
H.P. = the horse-power of the prime motor working the dynamo machine;
h.p. = the horse-power absorbed in the production of electrical work in the circuit;
λ = the intensity, in standard candles, of the electric light so arranged as to illuminate equally in all horizontal directions;
Λ = the intensity of the light in one particular direction; the light being arranged to give the maximum illumination (without reflectors) in this direction.

The energy of the current, or the mechanical equivalent of the work and heat produced by it *per hour*, will be

$$W = \frac{E^2 \times 2654}{R} \text{ ft.-lb.} = \frac{E^2 \times 1{\cdot}18}{R} \text{ foot-tons.}$$

The horse-power absorbed in the current $\left(\frac{\text{energy in ft.-lb.}}{33{,}000 \times \text{time in min.}}\right)$ will be

$$\text{h.p.} = \frac{E^2}{R \times 747}.$$

The ratio $\frac{\text{h.p.}}{\text{H.P.}}$ is the measure of the efficiency of dynamo-electric machines. In the case of Gramme's machine, under the best conditions, we have

$$\text{H.P.} = \text{h.p.} \times 1{\cdot}39.$$

The horse-power absorbed in the arc itself is

$$\text{h.p.} \times \frac{r}{R}.$$

The ratio of this latter value to h.p., or

$$\frac{r}{R} = \frac{\text{h.p.} \times r \times 747}{E^2},$$

is the measure of the efficiency of the electrical circuit in the production of the greatest quantity of light with a given quantity of electrical energy.

In the experiments with Gramme's machine made by the Committee of the Franklin Institute, the light, in standard sperm candles, produced by the voltaic arc was

$$\lambda = \text{h.p.} \times \frac{r}{R} \times 1044 \text{ (candles)}, \quad . \quad . \quad . \quad \text{(I.)}$$

when the intensity of the light was approximately equal in every

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direction. But, when the carbons are so adjusted as to give the best effect with the photometer in a given position, we may multiply the former value by 2·87, and we have

$$\Lambda = \text{h.p.} \times \frac{r}{R} \times 2996 \text{ (candles)}. \quad . \quad . \quad . \quad \text{(II.)}$$

Expressing these equations in a different form, we have

$$\lambda = I^2 r \times 1{\cdot}4, \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(I}a\text{.)}$$

and

$$\Lambda = I^2 r \times 4. \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(II}a\text{.)}$$

It should be remembered that these values are obtainable only under the most carefully-arranged conditions.

In regard to a point raised in your leading article last week: Although I quite agree that the light cannot be subdivided without very considerable loss, I should not be prepared to admit that, "if a given total quantity of light be produced with one hundred lamps, it is about one hundred times as expensive as if it were produced all in one lamp." If we use two lamps instead of one, and place them in series, the original arc resistance, l, is not necessarily doubled; indeed, it may be preserved constant, in which case we should have $\frac{C^2 l}{2}$ for each light, and the original value, $C^2 l$ for the two. And, if we place four lamps in parallel circuit, the total resistance may be reduced nearly fourfold, so that we may obtain twice the original current with half the E.M.F. in action. Thus $C^2 l$, or $\frac{E^2}{l^2} l$, becomes

$$\frac{\left(\frac{E}{2}\right)^2}{\left(\frac{l}{4}\right)^2} \times \frac{l}{4} = \frac{4 E^2}{l^2} \times \frac{l}{4} = C^2 l;$$

the theoretical value for each light being $\left(\frac{C}{2}\right)^2 l = \frac{C^2 l}{4}$, and that of the four $C^2 l$. The loss, when the light is subdivided, is, doubtless, due to an increase in the quantity of heat which must be expended before any luminous effect is produced.

With reference to the question put by Mr. Sprague, the intensities of the lights in the three cases he quotes would be—taking the arrangement of carbons which gives an equal light in every direction:—

With	60 Groves' cells	.....	340 candles.
,,	80 ,,	.....	448 ,,
,,	122 ,,	.....	685 ,,

And these values, as explained above, are to be multiplied by 2·87 if the greatest intensity of light producible in a given direction (by simple adjustment of the carbons) be required.

The old-fashioned voltaic arc, I may observe, is by far more economical, as a producer of light, than any of the new devices for the incandescence of solids.—I am, &c.,

DESMOND G. FITZGERALD.

THE MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

DEAR SIR: In the many attempts to utilise the Hughes' Microphone for speaking without a Bell's Telephone for hearing, it strikes me as very strange that no one has (to my knowledge) tried a Reiss Telephone as receiver. The first trial, with a very rough apparatus, enabled me to hear the ticking of a very small clock very distinctly, and afterwards to hear voices, particularly the voices of children, very fairly.

The starting point being settled, it must be easy by experiment to improve the arrangement, and to obtain fair and distinct articulation. In the hope that this hint may prove fruitful in the hands of some of your readers, I submit it for their consideration, and am, dear sir,

Yours very truly, C. V. DE SAUTY.

Gibraltar, 10th Nov., 1878.

ANSWERS TO CORRESPONDENTS.

J. J. W.—Armstrong's Hydro-electric Machine is briefly described in "Noad's Students' Text-book of Electricity," p. 29; also in "Jenkin's Electricity," p. 272. A more detailed description is given in "Noad's Manual of Electricity," also in Gavarret's "Traité d'Electricité."

M. K. S.—We think the original Gramme machine the most perfect in principle; although it has, doubtless, certain defects which a careful study of the theory of its action may remove. In regard to the most advantageous form of prime motor for working such machines, you may with advantage consult our own advertising columns.

LECTURE ON THE ELECTRIC LIGHT AT THE COLSTON HALL.

Professor S. P. Thompson, of the University College, Bristol, delivered a lecture at the large Colston Hall on the Electric Light, on Friday Nov. 8th.

He commenced by telling his audience they had met that evening to discuss the problem of the present age, and he wanted that problem to be discussed calmly and dispassionately upon its merits. At other ages there had been great questions before men just as this was before them now. Forty years ago the struggle was between locomotion by steam and horse power, and in 1811 they were first shown—by one residing in Broadmead, who was accused of bringing fire from below—how the ancient city could be lighted by gas; and now came the question, was electricity or coal gas to be the main source of light of the future; whether their streets, docks, ships, lighthouses, coal mines, factories, workshops, their public halls and their churches, were to be lighted by the electric light or by gas. The original discoverer of the electric light was at one time a Bristol man—they owed it, with many other grand discoveries, to the philosopher who 80 years ago was connected with the old Philosophical Institution at the bottom of Park-street—Sir Humphrey Davy. Proceeding more particularly to the subject of lighting, he must ask, why did a gas flame give them light? They were told it was because they had in the flame a large number of very minute particles which became intensely heated and therefore luminous. A flame, however hot it was, did not give much light unless there was a certain amount of solid matter with it. The lime light was on this principle; a piece of lime being made intensely luminous with an oxyhydro flame. The grand problem was how to produce the greatest luminosity with the least expenditure of heat. The London gas companies supplied a gas of only eleven sperm candles power; the standard required was fourteen candles, and the difference was made up by the excellence of the burners used. He trusted they would have even greater improvements in this direction [applause]. Coming to the electric light, he must first of all call their attention to a few simple electrical principles, and in doing this he should be aided with some views thrown on the screen. Having spoken of the formation of an electric cell, Dr. Thompson pointed out how a number of cells were arranged with a view to increasing the strength of the electric current. The power of a battery of a number of these cells was very great; thin wires of not very high conducting power would, as he would now show them, get red hot, and perhaps be completely burnt up if the current was sent through them. If the current was sent through two sticks of carbon, the points of which were placed near each other, the result was such intense heating that the electric light was produced. The lecturer then showed how wires were burnt up by a current from a battery of sixty cells arranged in a cellar below the hall, and then gave an illustration of what would occur when two carbon points were brought point to point. The electric light thus produced illuminated the hall very brightly, and was unpleasantly dazzling to the eyes. Proceeding with the address, the lecturer explained that as the light was formed the carbon points gradually wasted away, though with unequal rapidity. Very soon the points would get so far apart that the electrical arc would cease, and the lamp go out. This would happen very soon, and to obviate it several instruments had been devised. One of these, constructed by Duboscq, of Paris, was comparatively simple, the arrangement being such that a cessation of the electrical current consequent on the carbon points becoming too far from each other acted on an electro magnet, and induced it to release a spring, which brought the carbons within the requisite distance. Another regulator, and one that he was that evening to use, was much more complicated, the system of wheels being as nicely set as that of a watch. The electric light regulated by the last-mentioned apparatus was now shown, and its peculiarly penetrating power, and the sharpness of its shadows, owing to the light coming from a point, commented on by the lecturer. These properties of the light were inconvenient, and must be obviated to enable the light to be turned to any general use. In its undiffused brilliancy it had been adopted in lighthouses where piercing power was advantageous, and for scenic effects and magic lanterns. So sharp was it in its natural state that smoke from lamps not seen by ordinary light cast a shadow, and the flame of a candle also could be shadowed on the screen. Another inconvenience of the light as it was before them was that it required a battery downstairs, a battery to keep in order and which gave off nasty fumes. It required an expensive clockwork regulator very liable to get out of order, and, as he had just said, it was too bright unless it could be split up into a number of smaller lights. The difficulty of sub-division was a difficulty in its application. They could not split that light into two without losing a considerable portion. If they split it into

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two, they did not get half the power at each light, but only a quarter, and the two regulators would not work together; they put one another out. Modern appliances now came to their aid, and with them they found they could do without a regulator, and found that it was possible to, under certain circumstances, subdivide the light. The old system of a battery of cells and the regulator required skilled labour at every turn; the new system did not to such an extent require skilled labour. Faraday discovered that electricity could be got from magnetism, and the result was the invention of several sorts of machines, in which the current was obtained by coils of wire revolving under certain conditions near permanent or electric magnets. The "Alliance" pattern was an early sample of this class of machines. Mr. Siemens, the famous engineer of London, had also brought out a very successful machine; but one of the best, and one most used in Paris, where electric lighting had been paid a good deal of attention to, was the Gramme machine. It was very small and very convenient. In the Jablochkoff light the two carbons were made to burn at an equal pace by the current, instead of being sent continuously in one direction, being reversed very rapidly, and Jablochkoff dispensed with a regulator for keeping his carbons always the same distance apart by laying them side by side, so that they never were otherwise than the right distance, about one-eighth of an inch, from each other. The rods were separated from each other by a thin strip of plaster of Paris. Jablochkoff's candle was really a candle, and, like a candle, it burnt steadily away. Each candle cost 7½d., though he had heard that they could now be made for 5½d. Each candle burnt for about 1½ hours, and four candles were placed in each opal glass globe. By means of a commutator, a man who was employed to go round to each light turned off one candle and turned on another. The Gramme machine could be economically worked by the gas engine (engines by which so many horse-power could be obtained in a minute by merely turning on the gas), so that this was a new use to which gas had been put, and which would probably increase the consumption [cheers]. By Jablochkoff's arrangement one steam engine and generator sufficed for 16 candles; up to this point the Russian officer has succeeded in dividing the electric light. The lecturer here exhibited one of Jablochkoff's candles in its opal globe; but the light, though it illuminated the hall magnificently, could not be sustained for want of the necessary fittings. These lights were used, amongst other places, at the Magasins de Louvre, where there were 80, and the cost of each group of 16 lights, instead of being 3*l*. 12*s*. per day as with gas, was now said to be 2*l*. 11*s*. The Rapieff light, with its arrangement of four carbons, was being tried at *The Times* Office, London; and another lamp, which he thought would be a good substitute for the Jablochkoff, was the Wallace lamp. There were two square plates of carbon brought edge to edge, and the light having burnt away the substance in one place travelled further along the carbon. This light was very simple and cheap. One serious objection with these arrangements was, if once these lights went out, they must be relighted by putting a bit of carbon to connect the two sticks or plates. In 1847, King took out a patent for lighting by the carbon made red hot by a current being passed through it; this principle had been revived a month ago in England. And now he would speak of Edison's subdivision of the electric light, of which they had heard a good deal [cheers]. The sub-division was no new thing, it was known in 1848. The accounts of what Mr. Edison had now done had been greatly exaggerated by American papers and copied into the English papers. Scientific correspondents of his in America, whom he had every reason to trust, had seen Mr. Edison, and told him (the lecturer) that his invention was a pretty scientific toy and nothing more. The *Scientific American* had told them now what Edison's light was. He read it only yesterday. It consisted in illumination by passing a current of electricity through wire, which became white hot. To prevent the wire being burnt off by the force of the current when the heat became too great, the expansion of a metal plug shut off a portion of the current. The illumination was by incandescence, and not by the electric arc. He would give them an illustration of what was meant. He had fixed in a frame seven spiral wires, some distance from each other, but connected with wire to each other. On sending the current through them they became white hot, and to an extent luminous, and he could shut off part of the spirals without any difficulty. He could not show them Mr. Edison's particular device, but he could tell them that any system of lighting dependent on heating a number of spirals of wire would fail, because of the loss from the subdivision; they did not get from the seven spirals as much light as they would if they had sent all their electricity through one. Mr. Edison had made them some wonderful discoveries; the electric pen, the phonograph, the duplex and quadruplex system of telegraphy, but he thought he might say when he invented he did not talk, and when he talked he did not invent—[laughter]—and his talk through American newspapers about sewing machines, &c., being worked by electricity with economy was nothing but nonsense. In a very interesting manner, and with views thrown with the electric light itself on a large screen, the lecturer proceeded to narrate the various uses to which the light had been put and could be put; in workshops, railway stations, constructing bridges, docks, or other large works; in men-of-war and ships the light had been and could be used with advantage, and its usefulness had been manifested especially in several lighthouses, English and foreign. The light from a lighthouse near Dublin enabled him one night to see the time by his watch six miles distant. It had been used in amusements, and was peculiarly valuable where a white light was required for dealing with colours. He showed that ribbons brilliant by the electric light were comparatively dingy by gas light. Another thing was they could photograph by the electric light, they could not by the gas light, because these invisible, so to speak, chemical rays were absent in the gas light. Those phosphorescent clocks that were rendered luminous by exposure to sunlight could be also rendered so by the electric illumination. It was safer than gas, and some French insurance companies charged a lower premium for places where it was used. Electricity in the form of a vacuum tube had been proposed instead of the safety lamp for colliers; it was absolutely safe, and could not fire explosive gas. The grand difficulty to the general use of the electric light was the waste in subdivision. It was good for large works, but it was in the present condition of electrical science absurd to talk of its being divided into a thousand or a hundred thousand lights all from one machine. Until they discovered a superior method of production to the Gramme machine, it could not supplant gas in the many corners and passages where it was so useful to have a small light, but where they would never think of having a great body of light. It might be cheaper when applied as a means of illumination at the Houses of Parliament, but do not let them forget the immense outlay before the light could be had. The Jablochkoff system for sixteen candles necessitated a preliminary expenditure of 600*l*. Statistics differed as to the working cost. Some said it was as much as 2*s*. 2½*d*. per thousand candles; others said 3¾*d*., others 2⅝*d*. He was told, if they made it with the gas-engine, it was as low as 1*d*. per hour. The cost of the same illumination with gas would be 1*s*. 2½*d*.; wax would be dearer. In concluding, he would refer to the extraordinary effect the light had on gas shares. He took the last half-year's balance-sheet of the London Gas and Coke Company, and found, out of a revenue of over a million pounds, 900,000*l*. was received from the hire of meters and the supplying gas to private places; 200,000*l*. was produced by the sale of residual products, and only 65,000*l*. was paid for street and public lighting. Five per cent. of this, the worst paying 5 per cent. of the whole, for 11,000*l*., had to be paid in repairs and lighting. Taking the figures of their own Bristol Company, he found that the income was 73,000*l*., of which 51,000*l*. came from the hire of meters and the private supply of gas, 14,000*l*. from the sale of residual products, and public lamps paid 7,000*l*., while 2,000*l*. had to be had back in repairs, &c. Only 5,000*l*. out of the 73,000*l*., or 6¾ per cent. from Bristol. Suppose the electric light came to be universally used for street lighting, it would in the one case knock off 5 per cent. and in the other 6¾ per cent. from the takings, this percentage being the worst part of the whole. Yet gas shares had gone down. He could not understand it. He had referred to improvements in gas burners. One was Sugg's burner, which gave a light of superior illumination at a greatly cheapened cost, and there was every probability there was a future for the gas light as well as a future for the electric light. One light was suitable for certain purposes and the other for other purposes; with the two they might have the best possible means of illumination. One word, and he had done. Let them remember that gas lighting was in its time as much a scientific discovery as was the electric light. Why should they not be as proud of the one great discovery as of the other? He held that science promised a future of developed usefulness not to electricity alone but also to gas, and, if he succeeded in putting the question at issue, in the rivalry between those two children of science, in a light intelligible not to gas shareholders alone, but to intelligent citizens of a free city, he should rejoice that it had fallen to his lot thus to labour for the intellectual development of the age, and for the material progress of a great community.

NATIONAL ELECTRIC LIGHT CORPORATION, LIMITED.—Capital 500,000*l*., half of which is first to be issued in 10*l*. shares. It is proposed to purchase for 25,000*l*. in cash, and 5,000*l*. fully paid shares, the patent rights of Mr. J. Rapieff.

THE WERDERMANN LIGHT.—This system is to be tried at Paris by a committee, which includes among its members M. du Moncel, M. Edmond Becquerel, and M. Janin.

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NEW ELECTRO-MEDICAL APPARATUS.

By M. G. Trouvé.

The new portable apparatus of this skilful *constructeur* includes two forms of regulator for current-intermittences. One of these is an instrument of great precision, intended more particularly for physiological investigations; it gives, each second, the number of intermittences to within one per cent. The second, although less accurate, has a limit of error of not more than one-fifteenth of a second, and is adapted for ordinary medical purposes.

The importance of a means of regulating the number of intermittences in the faradisation current is fully recognised; nevertheless, medical electricians have hitherto generally contented themselves with using the ordinary vibrating armature, which allows of the variation of the intermittences within certain limits, but without indicating their number. A few physiologists, it is true, have used certain means for controlling the number of reversals or interruptions of the current; but these contrivances did not allow of a variation between sufficiently wide limits, neither were they portable or sufficiently moderate in cost for general use. These objections were applicable to the clock-balance as used by Duchesne, of Boulogne, to the metronome, and to Masson's wheel.

Wishing to test the influence of slow or rapid intermittences on the action of the heart and in muscular contractibility in certain cases of paralysis, Dr. Onimus applied to M. Trouvé, who thereupon designed and carried into effect the portable apparatus which was recently presented to the Société de Physique, and which we now describe and illustrate.

The apparatus consists of a slide induction coil (fig. 1), with independent primary and secondary bobbins, a battery formed of the hermetically-closed reversal cell (fig. 5) of M. Trouvé, various accessories used in electro-therapeutics, and a special regulator, which is the principal feature of novelty.

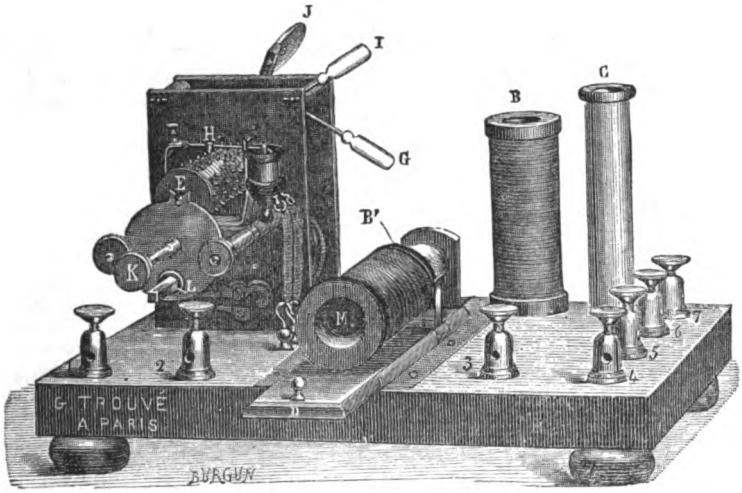

Fig. 1.*

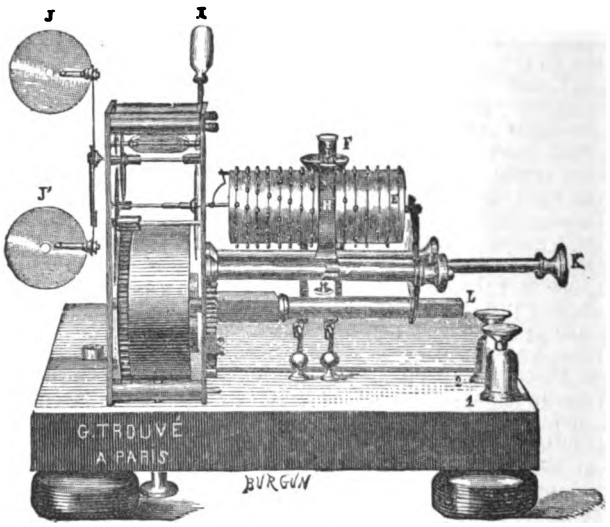

Fig. 2.†

This regulator or interruptor (fig. 2) is composed of a cylinder divided into twenty parts in the direction of its length. At the first division is placed a single projection or pin, at the second division two such pins, and so on in arithmetical progression, the pins being arranged in circles around the cylinder. This is moved by clockwork, regulated by means of a fly-wheel, so that any requisite number of revolutions per second may be obtained. A stylet, which is moveable in a direction parallel to the axis of the cylinder, may be brought successively opposite to all the divisions upon the latter, in order to interrupt the current as many times as there are pins at any particular division.

Supposing the stylet to be opposite the first division, where there is but one pin, then, if the cylinder revolves but once in a second, the current will be interrupted every second; and the interruptions may be increased to 20 per second by shifting the stylet along the cylinder. If the cylinder revolves five times per second, any number of interruptions from 5 to 100 per second may be obtained.

It may be of interest to explain the arrangement by which M. Trouvé causes the successive currents to be equal in duration whatever may be their number per second. Referring to Fig. 3, it will be seen that the stylet E moves between the two contact-pieces A and B, which are of platinum, and superposed upon a plate of ebonite. Either of these may at will be placed in the circuit by means of a spiral spring. It will be seen that, if the upper contact B is placed in the circuit, the latter will be completed at the exact moment when the stylet is raised by one of the pins upon the cylinder C. Now, since all the pins move with the same velocity, the period during which the stylet is raised will be invariable for any given velocity of the cylinder, whatever may be the number of times it is raised per second.

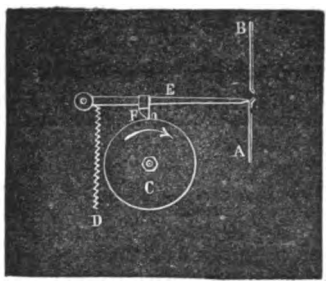

Fig. 3.

On the other hand, if the circuit is completed by means of the contact-piece A, the duration of the successive passages of the current will, as in the ordinary case, vary inversely as the number of interruptions. Thus, if the stylet be placed opposite the first division, the current will flow during one revolution of the cylinder; and, if it be placed opposite the twentieth division, the current will pass during the time occupied by one-twentieth of a revolution. In order to produce a series of induced currents exactly equal in duration—a result obtainable only with this apparatus—the circuit should be completed through the contact-piece B; and to produce either an interrupted current in one direction, or induced currents varying in duration, the contact should be made with A.

The binding-screws 1 and 2 are arranged so as to place the patient and the interruptor in the circuit of a battery, giving, of course, a current in one direction only, which may be interrupted

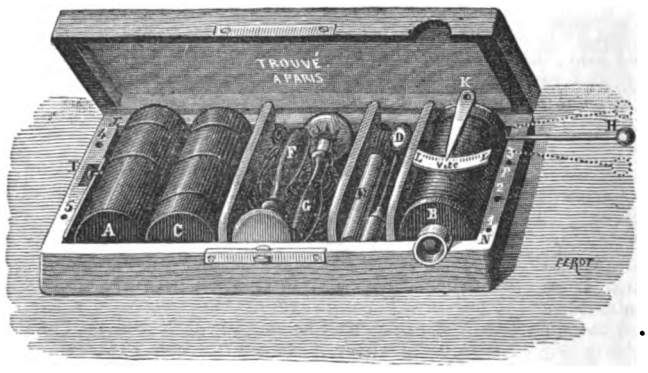

Fig. 4.‡

* M primary coil, C graduating tube, B and B' secondary coils to be attached to the slide, D slide for graduating the currents, E cylinder carrying pins and moved by clockwork, I lever in position to start the cylinder, G the same lever in position to stop the cylinder, 1 and 2 binding screws for interrupted battery current, 3 and 4 binding screws for primary battery.

† J and J' wings of flywheel offering variable resistances, K thumb-screw to move stylet.

‡ A reversible battery cell, B coil with armature and graduated limb, C ebonite case similar to battery cell but containing mercuric sulphate, D E F G various electrodes, H prolongation or extensible pendulum attached to armature, K indicating needle, L graduated limb, 1 2 connections for extra current, 2 3 ditto for induced currents, 1 3 ditto for both combined, 4 5 battery connections

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as often as required. The induced currents are obtained from the screws numbered 5 and 6; the extra current passes between 6 and 7; whilst both combined are obtained from 5 and 7.

The second form of regulator, for ordinary medical use, was recently presented to the Académie de Médecine by M Gararet. Its indicating needle and graduated limb are drawn in K and L (fig. 4). It may be briefly described as a vibrating armature of special construction, involving the principle of the pendulum, so that, by the movement of K, the number of its oscillations per second may be varied between tolerably wide limits. The figures marked upon the limb *l* are determined in each case by a simple experimental method involving a small chronograph and registering apparatus specially constructed for the purpose.

The reversible battery cell, represented in Fig. 5, has been

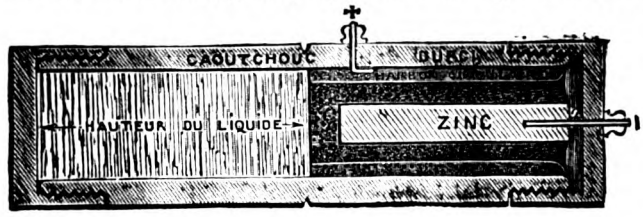

Fig. 5.

described in these columns on a previous occasion. When the fluid, a solution of bisulphate of mercury, occupies the position shown in the cut, the couple formed by the elements in the upper portion of the cell is not brought into action, and there is no consumption of material; but, when the cell is placed on its side or reversed, the couple is immediately rendered active.

ATMOSPHERIC ELECTRICITY.*

By Professor Palmieri.

Putting aside certain temporary apparatus designed to prove the existence of atmospheric electricity, such as the kite, captive balloons, the bow and arrow, and other similar contrivances, it may be said that for the daily observations of meteorology there have been used, in the first place, fixed conductors terminating in a point or "flame," next the moveable electrometer (Peltier), and, lastly, the fixed electrometer with moveable conductor (Palmieri and Thomson). The method of fixed conductors was triumphantly combated by Peltier, and I myself, without repeating what was demonstrated by the French physicist, showed further how, with that method, the observer might be deceived not merely as to the quantity, but also as to the quality of the induced electricity.†

Peltier's method, by use of the moveable electrometer, was undoubtedly a step in advance, but few were able to appreciate it; and, although Wheatstone recommended it to the British Association as the only one capable of giving results of any value, it attracted but little attention.

In 1850 I applied myself to the study of atmospheric electricity. I observed that, although Peltier's method was an important gain to electrical meteorology, nevertheless, it was not exempt from certain defects, owing to which it was impossible to get observations exact enough for comparison, and I endeavoured to find, therefore, some better method, as well as a thoroughly exact electrometer.

As regards the method, I studied the electrical manifestations occurring in the open air when two conductors are brought near to, or separated from, each other horizontally. I found that the tensions, which are manifested through contiguity, are of an opposite, whilst those which are obtained by separation are of the same nature as the electricity prevalent in the atmosphere. So that, in normal times, two conductors that are brought near to each other show negative electricity, but positive if they are separated. This law is, of course, inverted when negative electricity prevails in the atmosphere. The electrical tensions which we get in this way follow, as to their intensity, that of the air. These are the only facts which prove the electricity of bodies placed on the earth, or, if you will, the electricity of the earth; but, at the same time, they show that that electricity is induced from that of the air, and is not proper to them. If, then, this electricity of the earth is always opposed to that of the air, and follows exactly the phases of increase and diminution of the latter, it is clear that the former is induced electricity, and not *sui generis*, and thus one can understand the fact—often noticed by me—that, whilst at the University Observatory, the earth shows negative electricity to a very strong degree when two conductors are brought near to each other in the open air, at the Observatory of Vesuvius at the same time we get positive electricity—I say at the same time, for the observations were compared by telegraph. The electricity that is manifested at the approach or separation of two horizontal bodies being, then, exactly proportionate to that of the atmosphere, I concluded that from the former one might get the measure of the latter, since, to whatever method we have recourse, that which is measured is the force of the influence exerted on thoroughly exposed conductors by the electricity of the atmosphere. For reasons which it is not necessary here to repeat, I did not confine myself to the method of horizontal approach and withdrawal.

By the aid of water, I set about the study of the electrical phenomena of ascending and descending streams, and determined the origin of those electrical manifestations noticed by Tralles and Volta as occurring with the spray of the cascade.

With the descending jet I found, amongst other things, that when the vessel is insulated electricity homologous to that of the atmosphere manifests itself during the flow of the water. The same phenomenon occurs with other liquids, and also with pellets of lead, metal filings, and even with the ashes of Vesuvius.

(to be continued.)

* Translated from the *Elettricista*.

† I need scarcely repeat what has already been remarked by Peltier and so often verified by myself, namely, that the fixed conductors often remain for whole weeks perfectly mute, on account of electric dispersion. Volta observed that a fixed conductor required 5′ to attain the maximum of its charge; and this is in conformity with the known laws, since to become charged through the point takes time, and in this period, relatively a long one, losses will have occurred which, owing to their extent and variability, it would be impossible to calculate. Thus, frequently the whole is dissipated, as happens not seldom even to the conductor of an electric machine. What means then can be employed with fixed conductors? First, in regard to the deceptions which they occasion, I do not think that they can be avoided by use of the method proposed by Volpicelli, because even on calm days, whether owing to currents in the upper regions of the atmosphere, or to other causes not yet determined, there occur sudden and rapid changes through which the curve made with observations, taken at short intervals, nearly always turns out angular (see my "Lectures on Terrestrial Physics"). The fixed conductor, then, in a time of positive electricity will give negative electricity simply by a diminution of the inductive energy in the atmosphere, and this not only in stormy weather, but even when it is fine. This is why many times it has happened to me to get negative electricity with a fixed conductor, and positive with a moveable conductor. During the eruption of Mount Vesuvius in 1872, whilst the needle inclined itself towards the Observatory, the fixed conductor frequently signalled negative phases, the moveable conductor showing instantly a positive current.

THE SOCIETY OF TELEGRAPH ENGINEERS.—CABLE GRAPPLING.

The opening meeting of the present session of the above Society was held on Wednesday evening, the 13th of November, in the hall of the Institute of Civil Engineers, Great George-street, Westminster. The chair was occupied by Mr. W. H. Preece, vice-president.

Mr. Andrew Jamieson, C.E., was called on to read his paper on "Cable Grappling and Cable Lifting." The author remarked that, before entering on the main subject of the paper, it would be as well to briefly analyse the chief causes of the interruption and breakages to submarine cables. The chief causes might be enumerated as follow:—First, total breakage, due to abrasion, suspension between submarine eminences, insufficiency of slack, volcanic eruptions, or terrestrial disturbances, or possibly large masses of rock becoming detached and falling across the cable in their descent; second, in shallow water the cable was often broken from ships' anchors; third, faults were caused by teredos or other marine animals boring; fourth, break of the conductor, with perfect or good insulation; fifth, latent faults in the cable when laid, developing afterwards, or deterioration of the core, joints, or sheathing, and, sixth, and last, lightning. Reviewing the six causes, they came first to breakages due to abrasion. This cause was mainly attributable to the cable being swayed to and fro under the influence of tides, currents, &c., and the only means of guarding against them was to submerge the cable very carefully, and use as heavy a type of cable as possible. The floating in suspension was clearly due to insufficiency of slack, and hence the great importance of a thorough knowledge of the ground over which the cable was to be laid. Volcanic eruptions or terrestrial disturbances were actions over which we have no control, and for which at present no visible means of provision could be made, except that of using as heavy a type of cable as possible where they were to be apprehended. As to breaks by ships' anchors, this danger could only be lessened by using as heavy a type of sheathing as possible, and carefully marking off the ground by buoys or otherwise, and as far as possible avoiding anchorages. The frequent injury to the core by teredos or other marine animals might be guarded against by coating the core and servings with some anti-teredo substance, which would be either distasteful or fatal to the animal, and have no effect on the cable. Various means had been proposed with this object in view. The causes of interruption from a broken conductor, with perfect or good insulation of the core, were due to an over straining of the copper wire in the manufacture, or in paying out, or, perhaps, to the brittleness of the copper. The simple remedy for this kind of fault was taking great caution to have the core of the conductor thoroughly annealed, and capable of bearing a certain strain with elongation before breaking, and being careful not to put more strain on the same when twisting it into a conductor than was absolutely necessary to form a good lay. As regarded provision against latent faults in the cable when laid, or deterioration of the core, or joints, or sheathing, they must look for a remedy in a thorough system of electrical testing. With regard to interruptions caused

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by lightning, the remedy might be looked for in a good system of lightning guards. When, from any cause, a submarine cable was broken, or became too faulty for sending cable messages, a repairing ship was despatched as soon as possible to the spot. On arriving at the locality of the fault, the first thing to be ascertained was the depth of the water and the nature of the bottom, which was done by careful soundings. The most approved apparatus up to the present time was that of Sir William Thomson. Improvements had been made by himself and others on Sir William Thomson's machine, but he would not go into this matter at length, hoping it would appear in the Society's Journal. It was sufficient to say that Sir William Thomson's sounding machine was the best up to the present, both as regarded speed and accuracy. As regarded speed, they could easily take a sounding of 1,000 fathoms, or one mile deep, within one hour from the time of stopping the ship to the time of clearing away. With regard to accuracy, the wire had so small a diameter, it offered so small resistance to the action of the water, that it almost fell in a vertical line. So much as to catching the cable depended on the depth of the ground worked on, that too much importance could not be placed on the necessity of taking accurate soundings, both before the cable was laid and when repairs were to be executed. During the operation of sounding, it was well, at the same time, to obtain any data as to tides and currents that might exist at the place, and to make due allowance for these and winds in order to facilitate future operations in sounding and grappling. After the sounding was obtained, the next thing to do, if nothing answering the purpose was there, was to place a marked buoy, to be made easily distinguishable. He had proposed for this purpose, a lamp which would clearly burn for ten hours on the plan adopted by Sir William Thomson in his patent mariner's compass, but that morning he received a letter from Sir James Anderson, who had written to Sir Richard Collinson, the Deputy Master of the Trinity House, asking some questions as to what plans they were carrying out as to lighting buoys. In his reply, Sir Richard Collinson stated that compressed gas had proved a complete success. It was a very dangerous thing, indeed, for a ship, repairing a cable, say, in November, to lose sight of the buoy, for they would lose their "ground" in the night, and in the morning it might be some hours before they they regained the lost position. They would, therefore, see the advantage of a good light, and it would clearly be a great boon to those who had to repair the cable as well as to the shareholders and others, if some convenient and effective plan were devised for keeping the repairing vessel on the "ground" in the night. Having ascertained the depth of the water, the nature of the bottom, if possible, and currents, winds, &c., and fixed the position of their marked buoy, they were ready to commence grappling. He then alluded to the grapnel system now in use, illustrating his remarks by reference to a plan attached to the black board, showing the whole process; and next described the various parts of the grapnel system, observing that the grapnel itself was of various forms and sizes, according to the nature of the ground to be worked on. He then described the process of picking up the cable. When lowering the grapnel, when it came to within thirty or forty fathoms of the bottom, the ship should be moved slowly ahead, and care should be taken not to pay out too much rope in excess of the depth. Having taken precaution that all necessary stoppering and appliances were at hand to hook the cable, the ship should be, as far as possible, brought head to wind and tide, and should not be worked against any local circumstances that might be in the way. The responsible telegraph engineer, or officer in charge, then sat or stood on the grapnel rope, and he felt the action of the grapnel going over the bottom, watching the strain on the dynamometer. He could easily distinguish in shallow water between the cable being caught, or rocks engaged, but in working over deep water it required great experience and judgment to tell whether the cable had had been hooked or not. Rocks were a great source of trouble, and had caused no end of breakage to grapnels, ropes, &c., besides great waste of time. Further on he would bring before them a style of grapnel which was designed to obviate catching rocks and breaking any part of the grapnel system. Let them suppose, meantime, that they had hooked the cable and commenced picking it up. This was an operation which required considerable experience, and the ship had to be carefully and expertly handled, so as not to bring any undue strain on the cable, and to keep the grapnel rope as vertical as possible. Jerking and surging should be avoided in bringing the cable to the surface. The ease with which the cable might be picked up depended on the amount of slack laid; a safe rule would be to lay the cable with 1 per cent. of slack for every fathom of depth. Forms of grapnel had been devised for cutting one side of the cable, and picking up the other. . . Assuming that the cable had been successfully elevated to the bows of the ship, it should be secured to the grapnel nip. Stoppering the cable to the bows was dangerous, and he thought that some scheme could be devised to avoid this. The cable having been securely stoppered to each side of the grapnel it should be dropped. Supposing the good side of the cable had been buoyed and securely fastened, and everything being clear, it was time to pick up the faulty side. This was done by gently steaming the ship over the line of cable, and coiling it into a tank [described]. Care should be taken when the cable was brought to hand to see the exact nature of the fault; and all the information regarding it should be sifted and collected, with the view of preventing similar faults in future. He then described the further measures to be taken in repairing the fault, and subsequently drew attention to the grapnels used—the five-pronged grapnel on which the centipede grapnel was an improvement. Alluding to the grapnel which was more particularly the subject of his paper, he described it as a grapnel for relieving itself from rocks—working over the ground, however uneven, without any fear of being caught in rocks, or any part of the grapnel system being broken—and catching the cable in a manner so that it could not be displaced. [A model of the grapnel was on the table before him, and he showed the way in which it worked, amid the applause of his audience.] Thus, he continued, the expense involved by breaking the grapnel, ropes, &c., was avoided, as well as the great loss of time. Other grapnels had been devised for other, and very good objects. He then alluded to Mr. Lambert's grapnel, the object of which was to save labour, expense, insecurity, and time in lifting a cable, say two miles deep. His own grapnel, he said, was being successfully used by several companies. Speaking of grapnel chains, he said that a good three-quarter or seven-eighths wire was all that was necessary; it was sufficiently strong. It was attached to the grapnel by a shackle or swivel, which he proceeded to describe. Speaking of bow pulleys, he said it was awkward with one, and bad enough with two, and there ought to be three—one to grapple or pay out by, one to ease off one side, and one to pick up the other. There were many kinds of grapnel rope. A great improvement had been made on the ordinary rope—one formed of pure manilla, which he believed was the grappling rope of the future. They used it the other day in repairing a cable which was not very strong. He concluded by drawing attention to a diagram showing the strains brought on the grapnel rope.

The SECRETARY then, at the request of the chairman, read the salient parts of a short communication on the same subject from Mr. Lambert.

Sir CHARLES BRIGHT thought they had had a very complete account of the operations in grappling work. Mr. Jamieson had devoted a great deal of his paper to the grapnel. The form of grapnel they were most familiar with was the five-pronged grapnel. The centipede grapnel was not very generally used, except in shallow and low water, and on a soft bottom. The grapnel Mr. Jamieson had described was a remarkably good one, so far as he could see, never having used it himself; it filled up a gap in submarine operations. Several plans had been proposed for the same purpose, for he fancied he had seen something like it before, but he had never seen anything that seemed so thoroughly practical as the apparatus which Mr. Jamieson had shown them, and he would very much like at some time or other to be on board with him to see it in operation. He was sure it would do good service in cable grappling. As to the grapnel described as the work of Mr. Clark and Mr. Lambert, he entertained some doubt whether the stopper and cutter could be combined at the same time. He thought the apparatus described by Mr. Jamieson was thoroughly good, but he very much doubted the efficacy of Mr. Lambert's invention. Mr. Jamieson stated that the use of the grapnel would save breaking a great many others, and he (the speaker) would like to know its cost as compared with that of the ordinary grapnel. Judging from the look of the model before them, he should think it would run into a 50*l.* note. The history of the grapnel which they had had was particularly interesting. He quite agreed with Mr. Jamieson that no ship should ever be fitted without three bow sheaves.

After some remarks by Mr. JOHNSON, Captain HOFFE, Mr. WARREN, &c.,

Mr. JAMIESON, in reply, said with regard to Sir Charles Bright's remarks as to the price of his grapnel, that was rather a commercial question, but, at the same time, Sir Charles was not very far wrong. His grapnel did cost 50*l.*; with spare gear, &c., it would cost 60*l.* The ordinary one cost about 15*l.*, but the advantages were in favour of the former, as it prevented a great deal of trouble and loss of time, and would in a single day well repay expenses; it was also unbreakable. With regard to Sir Charles Bright's remarks as to grapnel ropes, he had gone very fully into this question in his paper, but had not referred to them in detail, as time passed so quickly. As to the manilla rope being slight, he reminded them that the cables which were laid were getting older and weaker every day, and in many places would not bear or stand grappling with a four by four or three by three rope, whereas in shallow water, if you grapple with a six-inch manilla rope, the bottom was indicated much more readily, and the ship could also be worked with greater facility as it was required to be worked.

The CHAIRMAN, in proposing a vote of thanks to Mr. Jamieson, said he was sure he might congratulate that gentleman on the exceedingly clear and able way—indeed, the elementary way—in which he had brought before them an extremely instructive subject. Mr. Jamieson had alluded to volcanic eruptions, sunken rocks, and other causes of breaks and interruptions; causes which one day or other ought to be brought before the Society. But one interesting fact, in particular, he had alluded to, and one which he (the chairman) had himself, in his short cable-repairing experience, met with as a terrible nuisance, through wrong charts. A nation like England, with a Navy like England, with so many half-pay officers, ought, he contended, to employ her experience and her ships in surveying our coasts and distant oceans with the view of correcting our charts, and giving our engineers reliable information to guide them in their operations. Mr. Jamieson had brought before them a very ingenious apparatus, and he was sure that they were always glad there "to see a little evidence of the fact that invention *does* still exist in England." The cry for some time past had gone forth that invention had left the shores of England and had gone to the other side of the Atlantic. In England there were no paid inventors to pander to the public enthusiasm, nor were they surrounded by newspaper correspondents who gathered their "facts" so largely from their fruitful imaginations; but here they had a way of steady going on and overcoming difficulties, and though they met with difficulties there was sufficient inventive skill among them to overcome them. He was sure they were all very much indebted to Mr. Jamieson for his paper, and in according him a vote thanks he was sure he was only repeating the opinion of every one present. He must also with their permission, and he was sure they would accord it, propose a vote of thanks to Mr. Lambert for his paper. He then expressed great pleasure in announcing that at the next "evening" a paper would be read by Major Webber "on Multiple and other Telegraphs at the Paris Exhibition," and the Harmonic and Multiple telegraphs of Mr. Elisha Grey, would be shown in operation. They were in great hopes that Mr. Grey would be present to describe his own apparatus.

TRAFFIC RECEIPTS FOR OCTOBER, 1878.

COMPANIES.	October, 1878. £	October, 1877. £	Increase. £	Decrease. £
Anglo-American Telegraph Company	54,150	49,510	4,640	—
Brazilian Submarine Company.....	13,138	11,387	1,751	—
Cuba Submarine Company.....	2,800 estd.	2,933	—	133
Direct Spanish Telegraph Company	1,106	914	192	—
Direct United States Telegraph Company ...	18,050 estd.	13,480	4,570	—
Eastern Extension Telegraph Company	23,393	21,388	2,005	—
Eastern Telegraph Company	41,678	37,402	4,276	—
Great Northern Telegraph Company	19,757	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company..	—	10,290	—	—
West Coast of America Telegraph Company.	—	—	—	—
West India Telegraph Company.....	—	—	—	—

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NOTES.

EASTERN EXTENSION TELEGRAPH COMPANY.—Dr. Muirhead succeeded, on the 22nd of November, in obtaining a balance, and in completing the arrangements for working the Madras-Penang section of this Company's cable on the duplex system.

THE "SOUNDER."—We are glad to learn that the Morse Sounder Instrument is finding favour with the Postal Telegraph authorities. A number of ink-writers have lately been superseded by sounders of the newest pattern at St. Martin's-le-Grand with very satisfactory results.

ANOTHER FORM OF TELEPHONE.—M. du Moncel has recently laid before the *Académie* a telephone which emits sounds readily heard throughout a large hall. This instrument, the invention of a M. Ader, is said to be constructed on a new principle: it contains a large membrane of parchment paper, upon which are disposed a number of very small electro-magnets, forming half a circle.

EASTERN EXTENSION TELEGRAPH COMPANY.—We learn by cable from the managing director of the Eastern Extension Telegraph Company in Australia, that the Legislatures of Victoria and New South Wales have ratified the agreement made with that Company for the duplication of the Australian cable; it has now to be signed by the representatives of the two Governments, which we shortly expect to be advised of. The extraordinary meeting of shareholders is fixed for the 4th December.

NATURAL POWER AND THE ELECTRIC LIGHT. — Sir William Armstrong is using the fall from a lake near his residence, by means of a turbine, to actuate a dynamo-electric machine. The light, which is said to be a mile and a half from the point where the electricity is generated, is used to illumine the picture gallery at Cragside. Such experiments as this will prove of the utmost service, as hitherto much has been said and little done to conduct the current over long distances. Sir W. Armstrong hopes, by means of an electrical engine at his house, to utilise to a still greater degree the source of power at his command.

TELEGRAPHY IN CHINA.—Extract from letter received from the Eastern Extension Telegraph Company's Superintendent at Shanghai, dated 10th October, 1878:—"Upon the subject of Telegraphs in China the latest news from Tientsin is that H. E. Li Hung Chang has instructed the Chinese students of Electricity at the college of that place to at once erect a telegraph line between Tientsin and Taku, and the survey for the Tientsin-Paonling-foo-Pekin line will be carried out. This looks hopeful as a start for Telegraphs inland, although foreigners are not allowed at present to have any hand in the work."

LECTURE EXPERIMENT.—An old experiment of De la Rive's may be used (M. Treve shows) to demonstrate to a large audience the influence of *pressure of contacts* on the intensity of a current. You hold in your hand the extremities of the two wires of an electro-magnet, and cause them to meet between its poles. In this position the sound of the rupture may be considerably varied, according as one wire is applied more or less strongly against the other. The sound, which is hardly perceptible when the two wires touch slightly, becomes like a pistol shot if they have been pressed strongly together.

THE ELECTRIC LIGHT.—The goods station of the Nicholas Railway at Moscow is being fitted with arrangements for illuminating the place with the Jablochkoff light. Hitherto the building has been lighted by petroleum, costing the company 25,000 roubles per annum. The *Cronstadt Vestnik* states that the further experiments with the electric light at Cronstadt forts have been eminently satisfactory. The success, however, of the electric light in illuminating the Black Sea ports during the Turkish war was largely indebted to the magnificent reflectors employed, and the Russian authorities, therefore, intend giving this portion of the experiments as much attention as the Jablochkoff light itself.—*Globe.*

THE TELEPHONE.—M. Louis Ollivier, of Elbeuf, considers that the flat form of the telephone receiving diaphragm interferes with the proper reproduction of the vocal *timbre.* This *timbre* is produced by the more or less complete blending of different harmonics. Helmholtz, by the aid of his resonators, has been able to isolate successively the fundamental tone and the different harmonics. After having thus analysed the sounds, he has recombined them by synthesis. In order to have a diaphragm which may vibrate in unison with various harmonics, Ollivier uses a concave plate of varying thickness, imitating, in some respects, the tympanum of the ear.

THE ELECTRIC LIGHT IN PARIS.—*La Bourse Parisienne* complains of the uncertainty existing as to the best form of electro-generator and electric lamp, and proposes that the town of Paris shall place at the disposal of competitors in this direction an open space as large as the Place de la Concorde. Here each inventor would be at liberty to exhibit his system, a jury would be stationed at a central point, data could be obtained, discussed, and verified, and a really comparative trial carried into effect. It is not anticipated that all the practical and economic advantages of any system could thus be determined; but it is suggested that the system which *primâ facie* appears the best should be provisionally adopted, and that its practical merits or defects should be subsequently reported upon.

SPIRAL ELECTRODES.—In the new excitement, when so many old ideas are dressed up and paraded as new, it is difficult to understand why some attempt has not been made to improve upon the idea of Allan, and to give us electrodes in the shape of a screw. Of the Allan lamp, we find a reference in 1852 as follows:—"The two electrodes are placed perpendicularly to one another, at the proper distance, and in this relation made to rotate by a simple clockwork movement. The result is that as the edge of the spiral, or contact point of the electrode, is in the course of being destroyed by the action of the current, and the distance between the two thereby increased, it is always regaining its proper position by the rotation of the electrodes producing fresh points for action. In this manner a constant distance or relation is preserved, and hence a constant steady light, the grand desideratum, the duration of which will depend only upon the length of the thread of the screw."

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THE EDISON ELECTRIC LIGHT.—In the *New York Sun* of November 15, an interview between a member of the staff of that paper and Mr. Edison is reported. Mr. Edison stated that he was positive his invention would show that the electric light was much cheaper than gas, and he was putting up a new building 125ft. long to demonstrate the utility and economy of his discovery. The building, he added, would be completed in two weeks. He proposes to light a park by the aid of an 80-horse power engine, starting with 2,000-candle lights. He will use the telegraph poles, with arms across the tops, placing 15 lights upon each arm. The main object is to ascertain many how many electric jets can be obtained from one-horse power. Mr. Edison says the experiment will enable him to discover any defects and make the invention complete before adapting it to the great cities. The thing could not be done in a day. He was working upon a principle without known laws to guide him, but experiments demanded both time and money. He believed that he would have the light in practical operation in about six weeks from that time.

THE GRAPHONE AND THE MICROPHONE.—The marvels of Professor Hughes's microphone and Mr. Edison's carbon transmitter have given a fresh impetus in America to the experiments of amateur telephonists, and at the United States Mint, Mr. Outerbridge, one of the chemists in the assay laboratory, has been very successful in his demonstrations. By the use of the microphone the tinkle of the new silver dollars falling from the coining press was distinctly heard at the distance of several hundred feet through the closed doors. It may be a surprise to any one but an electrician to be informed that these marvellous effects are transmitted by a wire nearly as fine as a human hair—one hundredth of an inch in diameter, by actual measurement—and this fine line would, doubtless, suffice for a great distance. The assayer takes this opportunity of suggesting to Mr. Edison, and the public at large, that the word "phonograph" was long ago appropriated to another science, as the dictionaries prove. "Graphone" would express the right idea, being taken from the two Greek words conveying the same sense; it also eliminates a "ph," one being enough, and it neatly harmonised with telephone, microphone, and similar words.

LIBELLING BY TELEGRAPH.—A Reuter's telegram from New York recently gave out that four Wesleyan missionaries had been eaten by New Zealanders. The report was discredited in some quarters, because, as a contemporary put it, cannibalism had been "abolished" in that country; and, indeed, it does turn out that not New Zealanders, but the natives of some other islands, were the offenders. These latter have been visited by a force of zealous Americans, who incontinently slew forty or fifty of the maneaters by way of compensation. The whole business is much to be regretted. Where a taste for missionaries is the subject of a telegram, the "place of origin" is of vital importance, affording as it does the only serviceable evidence as to whether or not cannibalism *has* been "abolished" there. Further, although it is hardly any business of ours, we venture to add that to provide forty or fifty ready killed natives is not exactly the way to abolish cannibalism among the survivors. They might not have the true missionary flavour, but something of the halo of martyrdom would attach to them, and—well, we are afraid it will be a long while before it is safe to land a cable on that island.

THE ELECTRIC TELEGRAPH IN SENEGAL.—The first line constructed in this French colony was opened in 1859; it connected Saint-Louis and Gandiole, a small town situated at the mouth of the river. The length of this line was 12 miles. In 1861 the island of Gorea was connected with the fort of Dakar, in the mainland, by a cable $1\frac{2}{3}$ miles long. This line, however, became unserviceable, and was not repaired; communication being at present maintained by means of canoes. But, in 1862, a line was established between Dakar and Saint-Louis, a distance of 133 miles. The only line since constructed is that from Saint-Louis to Podor, a trading station about 130 miles up the river. The actual length of line in working order is thus over 260 English miles. The Colonial Government is at the present moment considering the question of extending the last-mentioned line to Medina, which is 466 miles from Saint-Louis. Along this line would be situated all the stations of the upper river. It proposes also to connect Senegal with St. Vincent, by means of a cable 480 nautical miles long. The expense of this last step, by which the colony would be brought into communication with the mother country, would be about four millions of francs. The telegraphic traffic is not at present very active; the total revenue of the system, which comprises 11 stations, being 9,925 francs, and the number of private messages 4,470. The preservation of the overland lines is secured by the superstition of the natives, which makes them afraid to touch any object of which the use or appearance is unknown to them.

THE VALUE OF THE DUPLEX SYSTEM.—Sir J. Anderson, in reply to a criticism of Mr. R. Herring, gives the following facts relating to duplex working as applied to the various lines of the Eastern Telegraph Company :—"Upon our Marseilles-Malta cables, a distance of 825 miles, we are to-day working simplex 15 words per minute, duplex 26 words per minute. As far back as March, 1877, the working increase of speed upon our Bombay-Aden cable, which in electrical capacity about equals the Anglo-American cables, was 40 per cent. Upon the Aden-Suez cable, a distance of 1,460 miles, the increase was 60 per cent., and upon the Marseilles-Malta cable at the same date the increase was 71 per cent. To-day Marseilles-Malta averages 84 per cent. increase in regular working. Upon our Bombay-Aden cable, the first day duplex was established the increase was 40 per cent., on the second day 67·27 per cent., and on the third day 72·72 per cent. I have not at hand any more precise *data*, but I am within the mark when I assert that we can command a steady increase of 70 per cent. in favour of duplex over simplex upon all our long sections, and that we can as a *tour de force* upon our short sections between Marseilles-Bona and Malta-Bona reach 100 per cent. increase. Next, as to land lines, Mr. Herring says, while it is possible to send over 20 words per minute, on an average, between London and Valentia, it is not possible to send more than 24 words per minute by the duplex system. Upon this company's line to Marseilles, a distance of about 800 miles, including about 70 miles of cable across Channel, we exceed by simplex working a greater average than 25 words per minute. As an effort we have exceeded 40 words per minute. Frequently, when pressed, with our best operators, we have exceeded 30 words for hours together, and I do not hesitate to say that between London and Porthcurnow, a distance of 320 miles, we could maintain throughout the day, with good conditions of weather and line, an average of 25 words by simplex, and 54 with duplex, and I believe I am understating what we could do if called upon to prove it."

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EDISON'S TELEPHONIC AND ACOUSTIC RESEARCHES.

(CONCLUDED FROM PAGE 5.)

SHORT CIRCUITING TELEPHONES.

A number of the telephones invented by Mr. Edison may be classed together as short circuiting, or cut out telephones. The principle upon which they act might thus be briefly stated :—In vibrating, the diaphragm cuts from the circuit resistances, which are proportional to the amplitude of the vibrations. A transmitter constructed upon this principle is shown in Figure 16 (devised March 20, 1877). A lever, L, of metal, vibrating in a vertical plane, rests at one end upon a strip of carbonized silk, C, which is part of the primary circuit of the induction coil, I. In the course of its vibrations the lever cuts from the circuit parts of the silk, the current passing temporarily though the lever. Another, acting on the same principle, but differing considerably in construction, is shown in Figure 17 (devised August 21, 1877). A fine wire, W, of high resistance, is wrapped around a cyclinder in a spiral groove. The wire forms part of the primary circuit of the coil, C. A spring, S, of metal, in the form of an ellipse, is fastened at one side to the diaphragm, while the other side presses against the uninsulated wire upon the cylinder. The diaphragm in moving toward the right flattens the spring, making it impinge upon a greater number of convolutions than it would if the motion were in the opposite direction. The resistance of the circuit depends, therefore, upon the position of the centre of the diaphragm. The disadvantage of this arrangement is that either a whole convolution or none at all is suppressed from the circuit, rendering the current rather more intermittent than pulsatory.

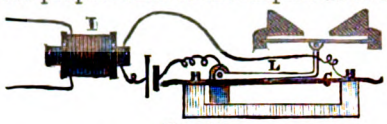

FIG. 16.

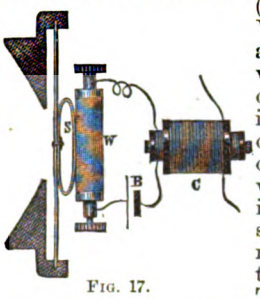

FIG. 17.

In Figure 18 (devised October 21, 1877), a similar spring rests upon a narrow strip of metal, on the surface of a glass plate. The film is shown in perspective at F, and consists of a fine strip of the silvered surface of a mirror, the rest of the burnished metal having been removed. The action of this instrument is similar to that of the instrument shown in Figure 16.

FIG. 18.

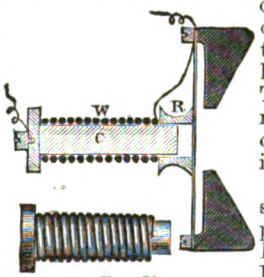

FIG. 19.

Still another form of short circuiting telephone is shown in Figure 19 (devised November 1, 1877). A spiral spring, W, is wrapped around a cylinder, the diaphragm pressing against the last turn, so that, in vibrating, the convolutions approach or recede from each other. A very slight motion of the diaphragm is sufficient to cause the first few coils to come together; and, in general, the number of coils that thus touch each other is dependent upon the amplitude of the diaphragm's motion. The wire is included in the primary circuit of an induction coil, so that the resistance of the circuit fluctuates as the diaphragm vibrates. This wire has also been used as the primary of the induction coil itself with better results.

CONDENSER TELEPHONES.

Telephones in which static charge, instead of current strength, is made to vary in unison with the vocal utterances, have also been tried with success by Mr. Edison. The forms shown in Figures 20 and 21 (devised February 9 and December 10, 1877) differ only in construction, not in principle.

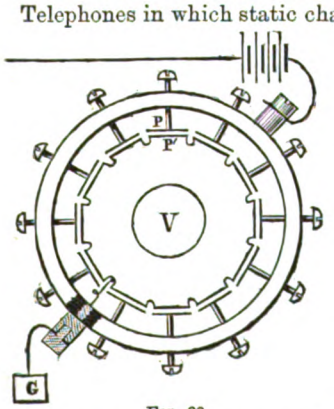

FIG. 20.

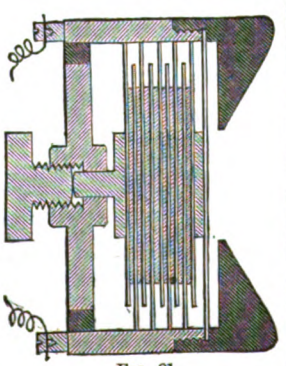
FIG. 21.

The former consists of a circular vocalising chamber with mouthpiece at V. The chamber is surrounded with plates, which are connected with each other and with the ground. These plates are free to vibrate, and are shown in the figure in section, as at P'. Immediately behind each of these stands a similar plate as at P, held at its centre by an adjusting screw. The outside row of plates are electrically connected with each other and with the battery which goes to line. When the inside row of plates vibrate under the influence of a sound the distance between the plate varies and changes their static capacity.

In Figure 21 the plates are arranged as in the ordinary form of condenser. An initial pressure is put upon them by a screw bearing in the solid frame of the instrument. The diaphragm, in vibrating, varies the distance between the plates; this alters their static charge, and affects also the electric tension of the line.

The resistance of a conductor is dependent upon its shape. If an isometric block of metal be drawn out into a wire, its resistance may be indefinitely increased. This fact lies at the basis of several ingenious telephones invented by Mr. Edison. The one shown in Figure 22 (devised August 17, 1877) is of exceedingly simple construction. A globule of mercury, M, rests upon a slightly concave plate of metal. A needle from the diaphragm indents its upper surface, and as it vibrates slightly alters the shape of the globule. This alteration, though exceedingly small, is sufficient to vary the resistance of the telephonic current considerably.

FIG. 22.

It is a peculiar characteristic of a globule of mercury that it changes its original shape during the passage of a current through it. Mr. Edison has made an application of this phenomenon in the telephone receiver shown in Figure 23 (devised August 19, 1877). The globule of mercury, M, is placed together with a conducting solution in a U shaped tube. The currents from a transmitter, passing through the contents of the tube, elongate the mercury. This agitates the liquid, and vibrates the float, F, which is fastened to the centre of the diaphragm.

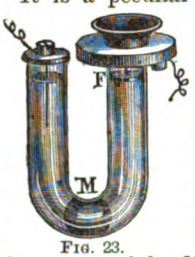

FIG. 23.

THE VOLTAIC PILE TELEPHONE.

We have shown in figure 24 (devised August 25, 1877) an instrument known as the pile telephone. A piece of cork, K, fastened to the diaphragm, presses upon a strip of platinum which is attached to a plate of copper. The latter is one of the terminal plates of an ordinary voltaic pile. The other terminal plate presses against the metallic frame of the instrument. When the pile is included in a closed telephonic circuit it furnishes a continuous current. The strength of this current depends upon the internal resistance of the pile and its polarisation, and these are varied by vibrating the diaphragm.

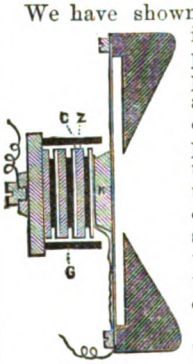

FIG. 24.

A convenient and peculiar form of receiver used by Mr. Edison is shown in Figure 25 (devised August 30, 1877). It is like the ordinary magneto telephone, except that the circular diaphragm is replaced by a strip of thin iron, the edges having been bent so as to render it stiff. We mention it simply because it demonstrates the fact that it is not essential that a circular diaphragm be used. A novel and purely mechanical telephone is illustrated by Figure 26 (devised August, 1877)

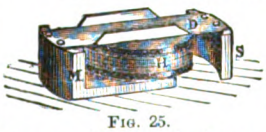

FIG. 25.

FIG. 26.

In place of a line wire, the illuminating gas contained in gas pipes is used. It is calculated for short distances only, as it is essential that the gas used in communicating offices should be drawn from the same main pipe. In the Figure, P is the main pipe. The telephones are represented at T and T'. The instrument is merely a cone fastened by its apex to the gas pipe

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in place of the burner. The larger end is closed by a thin circular diaphragm. The vibrations are conveyed from one diaphragm to another through the medium of the gas. The phonograph and telephone when combined form an instrument known as the telephonograph, of which Figure 27 (devised August 17, 1877) is a representation. The drum of the phonograph is shown in section. The diaphragm, instead of being vibrated by the voice, is vibrated by the currents which traverse the helix H, and which originate at a distant station. The object of the instrument is to obtain a record of what is said at the distant office, which can be converted into sound when desired.

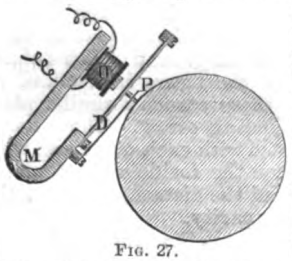

FIG. 27.

THE MOTOGRAPH.

The motograph receiver, from which we have been accustomed to hear sounds almost destitute of quality, has, by a little modification, become an articulating telephone.

It works quite well in conjunction with the Edison carbon transmitter. In Figure 28 (the form shown was devised November 23, 1877) the back of the motograph receiver has been removed, showing its construction. Within the drum D is contained the decomposing solution, and the covering surrounding the drum is kept constantly moist by capillary action. A metallic spring attached to the centre of the diaphragm rests upon the drum. While receiving the drum is revolved by turning the milled screw at A.

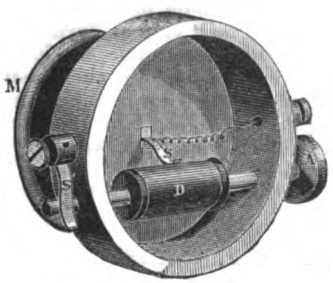

FIG. 28.

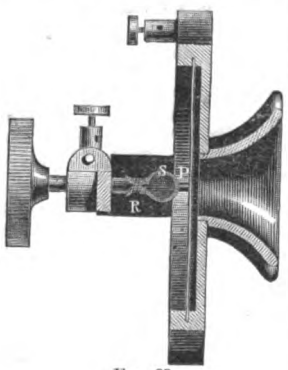

FIG. 29.

Mr. Edison's musical transmitter is shown in Figure 29. The point P, projecting from the centre of the diaphragm, impinges upon a wrapping of platina foil covering a small drum of rubber capable of adjustment by a thumb screw.

THE TASIMETER.

Figure 30 shows in perspective the latest form of the Edison microtasimeter, or measurer of infinitesimal pressure. The value

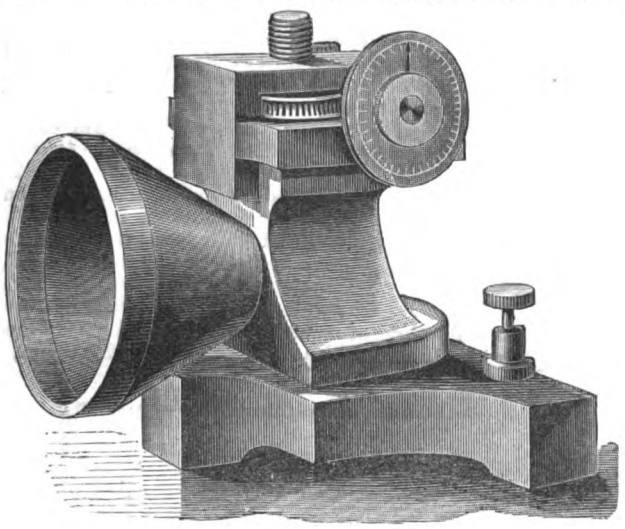
FIG. 30.

of the instrument lies in its ability to detect small variations of temperature.

This is accomplished indirectly. The change of temperature causes expansion or contraction of a rod of vulcanite, or other material which changes the resistance of an electric circuit, by varying the pressure it exerts upon a carbon button included in the circuit. During the total eclipse of the sun, July 29, 1878, it successfully demonstrated the existence of heat in the corona. It is also of service in ascertaining the relative expansion of substance due to rise of temperature.

In Figure 31 the important parts are represented in section, affording an insight into its construction and mode of operation. The substance whose expansion is to be measured is shown at A. It is firmly clamped at B, its lower end fitting into a slot in the metal plate, M, which rests upon the carbon button. The latter is in an electric circuit, which includes also a delicate galvanometer. Any variation in the length of the rod changes the pres-

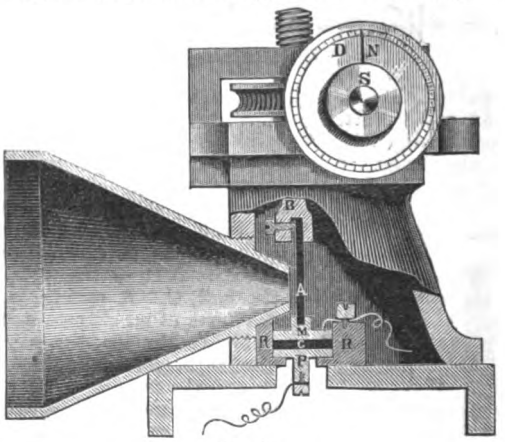

FIG. 31.

sure upon the carbon, and alters the resistance of the circuit. This causes a deflection of the galvanometer needle; a movement in one direction denoting expansion of A, while an opposite motion signifies contraction. To avoid any deflection which might arise from change in strength of battery, the tasimeter is inserted in an arm of the Wheatstone bridge, while the galvanometer is used in the bridge wire of the same.

In order to ascertain the exact amount of expansion in decimals of an inch, the screw S, seen in front of the dial, is turned until the deflection previously caused by the change of temperature is reproduced. The screw works a second screw, causing the rod to ascend or descend, and the exact distance through which the rod moves is indicated by the needle N on the dial.

The instrument can also be advantageously used to measure changes in the humidity of the atmosphere. In this case the strip of vulcanite is replaced by one of gelatine, which changes its volume of absorbing moisture. The delicacy of the apparatus to heat is remarkable, and far exceeds that of any other apparatus; when adjusted moderately delicate the heat of the hand placed in line, with the cone of the tasimeter 30 feet distant, causes the spot of light of the galvanometer to leave the scale.

THE AEROPHONE.

The aerophone, an inventiou of Mr. Edison's, for amplifying sound, has already attracted considerable attention, though, as yet, it has not been perfected.

Its object is to increase the loudness of spoken words without impairing the distinctness of the articulation. The working of the instrument is as follows:—

The magnified sound proceeds from a large diaphragm, which is vibrated by steam or compressed air. The source of power is controlled by the motion of a second diaphragm vibrating under the influence of the sound to be magnified.

There are three distinct parts to the instrument:—

A source of power.

An instrument to control the power.

A diaphragm vibrating under the influence of the power.

The first of these is usually compressed air, supplied from a tank. It is necessary that it should be of constant pressure.

The second, shown in section at Figure 32, consists of a diaphragm and mouthpiece like those used in the telephone. A hollow cylinder is attached by a rod to the centre of the diaphragm. The cylinder and its chamber, E, will therefore vibrate with the diaphragm. A downward movement lets the chamber communicate with the outlet H, an upward movement with the outlet G. The compressed air enters at A and fills the chamber, which in its normal position has no outlet. Every downward

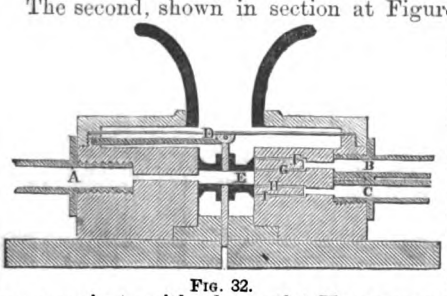

FIG. 32.

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vibration of the diaphragm will thus condense the air in the pipe C, at the same time allowing the air in B to escape *via* F. An upward movement condenses the air in B, but opens I.

The third and last part is shown in section in Figure 33. It consists of a cylinder and piston, P, like that employed in an ordinary engine. The piston rod is attached to the centre of a large diaphragm, D. The pipes C and B are continuations of

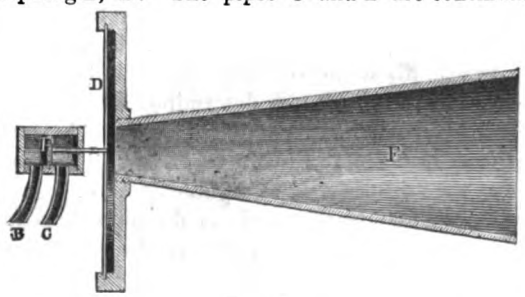

Fig. 33.

those designated in Figure 32 by the same letters. The pipe C communicates with one chamber of the cylinder and B with the other. The piston, moving under the influence of the compressed air, moves also the diaphragm, its vibrations being in number and duration identical with those of the diaphragm in the mouthpiece.

The loudness of the sound emitted through the directing tube F is dependent on the size of the diaphragm and the power which moves it. The former of them is made very large, and the latter can be increased to many hundred pounds pressure.

G. B. Prescott.

THE REGNIER LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of the 16th inst. you publish an article "On the Present State of Electric Lighting," by J. N. Shoolbred, B.A., Memb. Inst. C.E., in which the various regulators hitherto brought out are described. Allow me to draw your attention to the "Lamp Regnier," which has been well known in Paris for the last six months, and is now to be introduced in this country. This "Lamp Regnier" is a regulator, which is adapted to be used in private houses, hotels, warehouses, &c. It is the best for dividing the electric light. One small Gramme Machine, and any other dynamo-electric machine of same strength, requiring only 1½ horse power, will supply *ten* Regnier lamps, each lamp equal to eighty Carcel lights. For 100 lamps less than 10 horse power would be required. One, two, or four lamps, can be worked by a small battery, therefore do not require mechanical power. The light of one or more lamps can be extinguished and turned on again without changing the lights of the other lamps. I am just preparing to exhibit these lamps, and, when ready, I will send you word. The patentees of Regnier's Lamp have put the sale of the English patent exclusively in my hands, and I shall be glad to give any further information.—Yours, &c.,

Louis Simon.

[Mr. Regnier's work has already been noticed by us, *vide* p. 62, Vol. I.—Ed. E.]

A VOICE FROM WONDERLAND.

TO THE EDITOR OF THE ELECTRICIAN.

Two wond'rous babes, long years gone bye
Were born, unlike each other;
The Ornamental one was I,
The Useful my big brother.

While old, and stale, and dull, grew he,
I kept as young as ever:
All Europe's now in love with me
So lightsome, sweet, and clever.

Clever indeed: And some folks say
I'm their own magic baby,
Who'll work you *miracles* (for pay);
But this is as it may be;

For sure 'gainst Nature's will it is
To eat and have your cake;
And, as to probabilities,
There's been a slight mistake:—

More sails don't make more wind, my friends;
Nor watering more good stew;
One candle lighted at both ends
Won't burn as long as two.

November, 1878. Electric Light.

THE MICROPHONE.

AS CONSTRUCTED BY M. TROUVÉ.

We have already noticed this form of microphone, and we have now the opportunity of more particularly describing and illustrating it. The apparatus in question, which has the appearance of a small dark lantern, the candle of which is replaced by a stick of carbon, is shown in Figs. 1 and 2 in circuit with a voltaic cell and the telephone of Prof. Bell.

It will be understood that the carbon pencil unites two disks of the same material forming the top and bottom of the instrument. Thus constructed the microphone may be carried in the pocket without injury, its sensibility is augmented, and it is extremely convenient for many experiments. In Fig. 1 the instru-

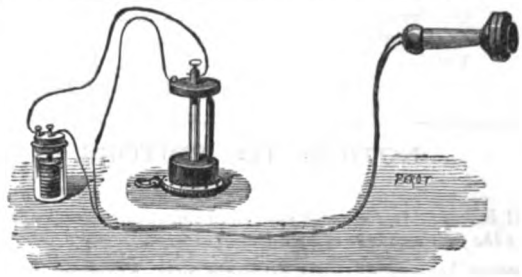

Fig. 1.

ment is placed upon a watch, the ticking of which is reproduced at a distance by the telephone, together with the sound of talking, the noise of footsteps, or the slightest vibration of the table due to any contact with it. In Fig. 2 the microphone is suspended

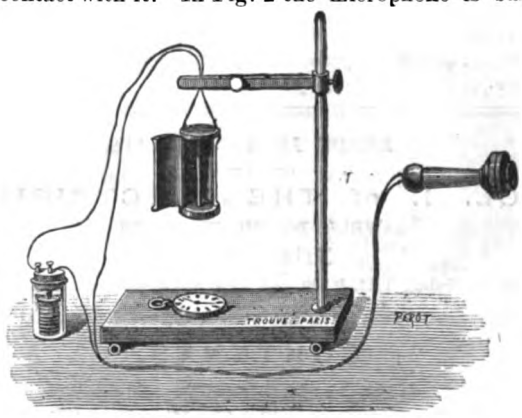

Fig. 2.

by the conducting wires, in which case it is extemely sensitive to atmospheric vibrations reproducing words spoken at a distance of 25 metres from the microphone, whilst, on the other hand, the ticking of the watch placed upon the stand, or slight contacts with the table on which the latter is placed, are scarcely heard in the distant telephone. Thus suspended in the middle of an apartment, the microphone reveals all its secrets; the *timbre* of the voice being as perfect as though two telephones were used. Whether the instrument be suspended or not, the sounds produced by any insect imprisoned within it are magnified and reproduced.

Fig. 3 represents another form of the instrument, in which the

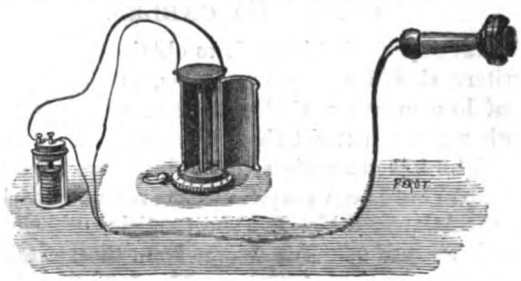

Fig. 3.

two disks of carbon are supported by a central stem, the carbon pencil being placed laterally. The upper disk is moveable upon the stem; so that the instrument may be adjusted by giving any desired obliquity to the carbon pencil. In any form of the instrument the greatest sensitiveness is obtained when the carbon pencil stands perpendicularly, and the least degree of sensitiveness when it is placed horizontally.

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THE ELECTRICIAN.

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DUPLEXED CABLES.

The great object of science is to obtain the truth. Scientific writers should never forget this, and yet such is the frailty of human nature that sometimes we are asked to give credit when no such credit should be awarded. Our contemporary, *Nature*, is generally so careful in its statements that many readers have been surprised at its recent remarks on duplexing the Atlantic cable. In a short article, published on November 14, we read:—"The change from theoretical to practical success is due to an American, Mr. J. B. Stearns, who, in 1872, succeeded in overcoming the main obstacle in duplex telegraphy, namely, what is known as the static discharge from the line. This Stearns accomplished by using a 'condenser,' and, further, he developed a system of 'duplexing' the line similar to the principle of the Wheatstone bridge." Now, dealing with one point at a time, we will refer from *Nature* of November 14th, 1878, to *Nature* of December 28th, 1876' or nearly two years ago. We here find the same paper saying that Stearn's success was "on the overland lines of the company to which he was connected." We call particular attention to this, because, whilst great efforts are being made to show that England is going backward instead of forward in telegraphic work, some credit has hitherto been given us as having practically done all that has been done with regard to cables and cable work. A determined effort is being made to force the public to believe that even in cable work the improvements are from foreign sources. The article in *Nature* of the 14th goes on to say:—"More or less successful attempts were afterwards made to duplex submarine cables, and in the early part of 1877 Mr. J. Muirhead succeeded in duplexing the cables of the Eastern Telegraph Company by his artificial condensers. But we believe that his success was only partial. Subsequently, Mr. Muirhead has been at work duplexing the Direct United States Cable with some prospect of success." Turning back to the issue for December 28th, 1876, we find: "In July, 1875, this system (Muirhead's), which is hitherto the most successful of all in submarine duplex, was first tried on the Marseilles-Bona (Algeria) Cable. . . ." The concluding sentence of the paragraph states that "These are the first practical successes in submarine duplex telegraphy," and we may add that the "these" refers solely to the successes of Mr. Muirhead. We have no wish to detract one iota from the credit due to Mr Stearns for his successes on land lines; but we ask that, in these days of progress, the plain facts shall be given, and that the public should not be allowed to believe that Mr. Stearns' successes occurred with cables as well as on land lines. If we are not mistaken, the whole article in *Nature* is calculated to mislead, and, in fact, Mr. Stearns has not yet succeeded in duplexing the Atlantic Cable; at any rate, the success is not sufficient for the Company to take charge and take the risks in future. On the other hand, besides succeeding in the Marseilles-Bona line in 1875, Mr. Muirhead, in 1876, duplexed the cables from Marseilles to Malta, and from Suez to Aden; in 1877, he was successful in applying the system to the cable from Aden to Bombay; and these were not "partial successes" but thoroughly practical and complete. In April of this year, as announced in early numbers of *The Electrician*, the Direct United States Cable was satisfactorily duplexed. This fact is mentioned by Mr. Herbert Taylor in a letter on the subject published in *Nature*, Nov. 21. He says: "Notwithstanding the difficulties, Dr. Muirhead and myself obtained a perfectly satisfactory balance, enabling us to transmit sixteen words a minute in both directions at the same time, between Ireland and Nova Scotia, a cable distance of 2,420 nautical miles." Since then the mixed cable and land line from London to Emden has been duplexed, and on the 22nd of this month Dr. Muirhead successfully completed the duplexing of the exceptionally difficult Madras-Penang cable. So far as we are at present concerned, these are facts which cannot be denied; and Sir J. Anderson, in a letter referred to in our "Notes," bears testimony to the value of the duplex system. It seems to us that in these discussions the name of Newall has been overlooked, and yet as early as 1855-6 he was on the high road to success, but, frightened at the expense involved in constructing condensers, his experiments were discontinued, and the idea of duplexing for the time passed away. In the article in *Nature*, Dec. 28, 1876, Newall's name is mentioned, as are also the names of De Sauty, Frischen, Siemens, Smith, &c., as having been engaged in conducting experiments in duplex-telegraphy.

It is not our purpose to decide what part each played in

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the effort to reach the goal; it is sufficient at present to show what Mr. Stearns and Mr. Muirhead have done. The former may claim from us acknowledgment for having revived interest in, and success in applying a system of duplex working to land lines; to the latter must be conceded the praise of having been the first practically to succeed in applying duplex working to cables, and who has at the present moment the satisfaction of knowing that more than ten thousand miles of cable are successfully at work through his labour.

MR. HERRING AND THE POSTAL TELEGRAPH AUTHORITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You have recently done me the honour to refer to my case against the authorities of the Post Office. It is, to my mind, perfectly clear that so long as the technical officers of the Telegraph Department are permitted to constitute themselves simply a society for mutual admiration, no inventor can safely entrust any of his ideas to them. At present, the Post Office Telegraph secretary and engineer are absolutely empowered, as will be seen from the following narrative, to do just what they please. Not only do the Premier and the Postmaster-General appear powerless to prevent gross irregularities, but even the commands of the Sovereign are utterly despised.

Not long since I came to the conclusion that it was idle to hope that justice would be done me by the Postmaster-General or his subordinates. Years had elapsed since my system of recording telegraph signals had been submitted to the authorities. I had expended several thousands of pounds on my invention, and had received the assurance that it would be submitted to an honest trial. I had again and again requested the Post Office authorities to keep faith with me, and, as well in justice to me as in the public interest, to submit my system to the necessary tests, conducted by competent persons, and had failed to induce compliance upon their part; and, finally, the subject matter of my demands having been declared by the Post Office authorities absolutely and conclusively disposed of by them, I found myself (unless I accepted the alternative of quietly submitting to the wrong which had been done me) compelled to seek redress in some other quarter.

In compliance with a suggestion made by General Ponsonby, the private secretary to the Queen, I addressed a letter to Lord Beaconsfield, stating generally the nature of my grievance, and received a reply to the effect that my communication should be addressed to the Postmaster-General. A further letter addressed by me to the Premier, pointing out the futility of addressing communications to the Postmaster-General, remained without a reply.

I then bethought me of my constitutional right of petitioning the Sovereign, and in the month of February transmitted through the ordinary channel—the Home Office—a petition to the Queen. On the 6th of March I received from the Home Office a letter stating that my petition of the 26th February had been duly "laid before the Queen," and "that Her Majesty had not been pleased to give any commands thereon." Having reason to believe that only a portion of my petition had been submitted to Her Majesty, it having been embodied in two communications, dated respectively the 22nd and 26th of February, I pointed out this fact in a letter addressed to the Home Office, but simply received a reply referring me to the previous letter addressed to me on the 6th of March.

Matters continued thus until the month of June, when I resolved on making one more effort to secure an official recognition, and possibly redress, of the wrongs which I complained of. On the 11th of that month I addressed a letter to the Home Secretary, stating that I was desirous of addressing to Her Majesty a petition "based upon the fact that I had been cruelly wronged of time and money by the unfair treatment which I had received from one of the principal departments of Her Majesty's service," and requested the Home Secretary to inform me "whether that subject was one upon which Her Majesty might be properly addressed." In order that the Home Secretary might become personally acquainted with the nature of my grievance, I enclosed a copy of my "Lecture on Personal Experiences of English Departmental Government."

On the 14th of June I received a reply, stating that the Home Secretary could give no opinion on a matter which was not before him, but that "a complaint of unfair treatment by any department of Her Majesty's Government, if properly embodied in a petition to Her Majesty, would be presented to her by the Secretary of State." No reply could have been more satisfactory or encouraging, and I felt that nothing remained for me but to state succinctly and clearly the manner in which I had been treated by the authorities at the Post Office, in order to secure, through Her Majesty's gracious intervention, a thorough and independent examination of the serious charges which I preferred against this department, with the consequent redress of the cruel wrong of which I complained.

I accordingly prepared my petition with great care. It set forth the history of my relations with the Post Office—the abortive and insufficient trial which had been made of my instrument by Sir William Thomson and Mr. F. Jenkin; the subsequent admission by the Secretary to the Post Office that a further trial was indispensable, and his written statement that such a trial should be made; the subsequent refusal of the Post Office authorities to assent to such a trial; my ineffectual attempts to induce them to render me common justice, and their final refusal either to correspond with me or to receive me. The petition concluded by enumerating the various points in which the authorities of the Post Office had broken faith with me, and humbly prayed Her Majesty to be graciously pleased to take such steps as might be necessary to secure for me redress.

This petition was transmitted to the Home Office on the 19th of June, accompanied with a letter addressed to the Secretary of State requesting him to present it to Her Majesty. I had not long to wait for a reply. It was as follows:—

"SIR: I am directed by Mr. Secretary Cross to inform you that he has laid before the Queen the petition which accompanied your letter of the 19th inst., and that it has been referred, by Her Majesty's command, to the Postmaster-General, to whom all further communications on the subject to which it relates should be addressed.—I am, sir, your obedient servant, A. F. O. LIDDELL."

On the receipt of this letter I was at first considerably astonished at finding that my petition had been referred, by Her Majesty's command, to the Postmaster-General—the very Minister of whose conduct I had so bitterly and so justly complained—and that all further communications on the subject to which my petition referred should be addressed by me to an official who had pertinaciously refused to pay any attention to my many letters bearing on the same subject. A little reflection, however, led me to view the matter in a different light. In ordering that my petition should be referred to the Postmaster-General, Her Majesty had no doubt been graciously pleased to command that the facts set forth in my petition should be duly investigated, and that the authorities of the Post Office, being alone familiar with the merits of my case, should present their answer to the serious charges advanced against them. My petition was substantially an indictment against the Postmaster-General and some of his subordinates, and it would naturally recommend itself to Her Majesty's sense of justice that before anything else was done they should have an opportunity of replying to my accusations.

On the 30th of June I accordingly addressed to the Postmaster-General a letter stating that I had been informed by the Secretary of State for the Home Department that my petition had, by Her Majesty's command, been referred to his lordship, and that all further communications on the subject should be addressed by me to him. I then concluded as follows:—"I shall be glad to hear that your lordship has received the petition, and that it is strictly accurate in every detail, and that your lordship has no reason for withholding what is due to me." In order, however, to rightly understand the precise grounds on which my petition had been referred to the Postmaster-General, and the nature of the communication with which it was accompanied, I wrote a few days later to the Home Secretary, requesting information on these points. To this letter I received a reply dated the 5th of July, stating that "my petition to the Queen was referred to the Post Office by Her Majesty as being the department which alone could deal with it, and that it was duly sent to that department on the 28th ultimo"

This laconic and far from satisfactory reply not unnaturally led me to conclude that the result of my petition to the Queen was, after all, simply to land me at the point from which I started, namely, on the doorstep of a public department, from whose officials I knew by experience it was vain to expect either civility or redress, and I therefore wrote to the Home Secretary reminding him of his statement, that "a complaint of unfair treatment by any department of Her Majesty's Government, if properly embodied in a petition to Her Majesty, would be presented to her by the Secretary of State," and pointed out that my petition contained various complaints of unfair treatment on the part of the postal authorities, and concluded with a prayer for redress. I also stated that up to that date (July 6th) my letter to the Postmaster-General of June 30th had remained unanswered. On the

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9th of July a letter was addressed to me from the Home Office duly acknowledging receipt of mine of the 6th, and stating that "The Secretary of State must decline to interfere further in the matter of my (your) claim, or to correspond any more with me (you) on the subject." I may add that the Home Secretary has most religiously kept his word.

Meanwhile I experienced no little astonishment at not receiving any reply from the Postmaster-General to my letter of the 30th of June, calling his attention to my petition which had been referred to him by Her Majesty's commands. My experience of the department would have naturally led me to view without surprise any inattention, however gross, to communications emanating from myself, but, in my innocence, I supposed that, when a subject exercised his constitutional right of petitioning the Crown, and when the Sovereign was graciously pleased to remit his petition for the careful consideration of one of the Ministers of State, it would have been impossible for such Minister to treat the Sovereign's mandate with disrespect, and pigeon-hole the petition as he would do a a private communication from an importunate suitor.

I accordingly called at the Post Office in order to obtain an explanation of the mystery, and was then informed by one of the officials that my petition would receive no attention from the Postmaster-General, and that no answer would be returned to my letter. This was on July 9th, but on the following day I received the following important communication from the Post Office :—

"SIR: I am directed by the Postmaster-General to acknowledge the receipt of your letter of the 30th ultimo, respecting a Memorial to the Queen which has been referred to his lordship by the Secretary of State for the Home Department.—I am, sir, your obedient servant, "C. H. B. PATEY."

As this letter was not very explicit, and simply communicated two facts with which I was already perfectly acquainted, namely, that I had written a letter to the Postmaster-General, on June 30, and that my petition to the Queen had been referred to his lordship, I addressed a letter to the Postmaster-General, repeating the request made in my former letter, that I should be glad to learn that my petition was accurate in every particular; that Mr. Patey, the writer of the letter of the 10th inst., was as conversant as myself with all the merits of the case; and that, if I received no communication to the contrary within a week, I should conclude that my petition was "strictly accurate in every detail." To this letter I received no reply; and I may as well state that, with the exception of the formal letter of the 10th July, acknowledging the receipt of a previous letter and of the memorial to the Queen, I have never, down to the present day, received any communication whatever from the Post Office in reference to the petition submitted by me to the Queen, and by Her Majesty's command referred to the Postmaster-General.

Having, as already stated, received a letter from the Home Secretary, declining "to interfere further in the matter of my claim, or to correspond with me any more on the subject," I felt that it would be culpable on my part to submit in silence to the treatment of the Postmaster-General, and that it became my duty to inform the Queen that the petition which had been referred by her commands to the Postmaster-General had, to all appearance, been thrown into the waste-paper basket. I was quite conscious that to address the Queen directly by letter was an unusual proceeding, but, under the circumstances, it will be seen that no other course was open to me.

I accordingly wrote to Her Majesty on June 16, stating that my petition, which had been referred to the Postmaster-General, had received no attention from that Minister, and that I had been verbally informed no answer would be given to it. I apologised to her Majesty for the liberty I had taken in addressing her, stating as a reason that the Home Secretary had said he would act no further in the matter. A few days later I received the following acknowledgment of my letter, dated from Buckingham Palace :—

"Major-General Ponsonby is commanded to express the Queen's regret that Her Majesty cannot personally interfere in the matter referred to in Mr. Herring's letter of the 16th instant."

I was very much disappointed by this reply, and again wrote to the Queen on July 20th, pointing out that, if Her Majesty was thus to ignore my petition, the result would be to perpetuate unfairness, and lower the dignity of the British Crown. To this letter I received the following reply :—

"Lieutenant-General Sir Thomas M. Biddulph is commanded to acknowledge the receipt of Mr. Herring's letter of the 20th instant, but regrets that nothing can be added to the answer which was returned to him by the Queen's command on the 19th instant."

In conclusion, I would observe that, if the subject possesses the right to petition the Sovereign, it cannot mean the barren right of addressing a complaint, the substance of which is to be communicated by a Minister to the Sovereign, and then, by the latter, to be referred to some department of State, to deal with it or not according to its own pleasure. It is needless to say our ancestors would never have struggled to secure so empty a privilege, nor would they have been guilty of the folly of giving it a place in the Supplementary Great Charter obtained by them after the expulsion of the Stuarts. The right of petitioning the Sovereign conveyed to their minds the idea of being able to make the Sovereign cognisant of an alleged grievance, and to obtain—if not redress, at least a judgment on its merits.

From no aspect of the case can it be said that justice was done me by referring my petition to the Postmaster-General, to be by him incontinently dismissed as undeserving of any attention whatever.

Whether my complaints against the Postmaster-General and his subordinates, as set forth in my petition, be well or ill founded, is also entirely beside the question. That question raises an issue which, in a country governed like ours, possesses a vital importance for every subject, because it may be the lot of any man to meet with ill-treatment at the hands of public officials, and, failing to obtain redress, he may, like me, proceed to exercise his constitutional right of petitioning the Sovereign. That right, however, I have shown to be perfectly delusive. Of course, if the British people are content to abandon one of the rights to which they laid claim at the time of the Revolution, and which is still solemnly affirmed in the Statute Book, no more remains to be said. It is, however, because I believe they are not inclined to relinquish it, and because I believe they still suppose that it furnishes a protection against oppression, that I have now shown it, by my own experience, to be "a mockery, a delusion, and a snare." If my experience is exceptional, it will be easy to demonstrate it. It would be highly instructive if a return was made to Parliament of the numbers of petitions presented to the Crown, say, during the present reign, and of the number of those in which redress was obtained, or even in which the complaints of the petitioners received any serious attention.—I am, Sir, your obedient servant, RICHARD HERRING.

27, St. Mary's-road, Canonbury, 26th November, 1878.

ATMOSPHERIC ELECTRICITY.*

By PROFESSOR PALMIERI.

The method of the descending jet seemed to me important, but, eventually, I put it aside for reasons which I shall shortly divulge. This method is, in substance, the one used by Thomson for so many years, without any one troubling himself to remember that it had been invented in Italy, although not only were my experiments published in a memoir read by me before the Accademia delle Scienze, but they are to be found in a compendious form in each of the five editions of my lectures before mentioned.

Relying upon the electrical manifestations of these jets, I next had constructed a curious electrical machine (*vide* "Terr. Phys.") which was formed of a series of conductors fixed by means of insulators on a horizontal axis so as to form a vertical wheel. It is evident that by spinning this wheel rapidly we should get in ordinary times positive electricity from each of the spokes which radiates upwards, and negative from each one that goes downwards, and that the maxima would correspond respectively to the vertical top and bottom. Electric communication being made at the maxima points, the tensions would naturally be opposite in character, and I find that if this wheel is made to revolve rapidly by means of a motor, I get a continuous flow of electricity better than with the descending jet. This curious electrical machine is described in all the editions of the above mentioned lectures.

I will not stop to explain why I did not resort to this simple and curious method for the ordinary daily observations of electrical meteorology. Suffice it to say that it did not seem possible to me to get with this apparatus as with that of the descending jet a method at once easy and precise of ascertaining the electrical dispersion.

I applied myself, therefore, to the before-mentioned method of the vertical ascending conductor, which I called "mobile conductor," wishing to denote rather the genus than the species, since the method of horizontal approach and separation, that of the jet and that of the wheel, are all of mobile conductors, and I have tried them all. How, then, can it be said that the apparatus of Thomson with the descending jet is one with a fixed conductor? and, as Professor Ragona, with a superficiality, not usual with him, agrees with Volpicelli in believing that my apparatus, because open to two influences—namely, that of the atmospheric electricity and that of terrestrial electricity—offers complex and in-

* Translated from the *Elettricista*.

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exact indications, I invite him to consider whether the descending jet itself is exempt from this twofold influence.

Some say that the earth is endowed with negative electricity, in spite of its potential being, as everyone declares, zero. Peltier was the first, as far as I know, to make an experiment with a view to strengthen this hypothesis. He placed under the roof of a room an insulated conductor charged with positive electricity, and on the floor of the same room another insulated conductor charged with negative electricity. Placing between these an electroscope reduced to zero, he witnessed a manifestation in raising it of + electricity, and in lowering it of — electricity. He concluded thence, that, if he obtained the same results with the electroscope in the open air, it might be considered proved that the earth and the atmosphere have opposite electricities; but then supposing the earth to be always charged with — electricity, he could not say how it was that sometimes the descending electroscope showed + electricity. The learned, however, unanimously agreed that to get the results obtained by Peltier from two conductors only one was necessary—for example, the upper one—so that the supposed electricity of the earth remains hypothetical. The only experimental proofs of the electricity of conductors, thoroughly exposed on the earth, are obtained from the phenomena of approach and separation, which show manifestly that the earth is amenable to the influence of the electricity of the air. It is said by some that the great majority of physicists hold the earth to be negatively electrified; but this supposed majority might have the goodness to prove it as I have proved that the electricity of terrestrial bodies is always proportionate and opposite to that of the earth. We will leave sacred orators to prove their assumptions by the authority of the holy Fathers, and content ourselves with endeavouring to find by experiments carefully conducted and interpreted our own proof.

I was the first to demonstrate, by means of experiments, the electricity of terrestrial bodies through the phenomena of approach, and I was the first to show that that electricity is induced from that of the atmosphere; and that hence it is always of opposite poles, and exactly proportioned to the influence exerted by the latter. This is why the method of horizontal approach, as it succeeds in obtaining for us the measure of the electricity induced from the atmosphere, can also give us the amount of its energy, and, this being granted, the mobile conductor, even allowing that it partakes of the double influence, will give a value proportionate to the inducing energy of the atmosphere whence that of the earth is derived, and which reacts on the mobile conductor with an equable and proportionate force. Volpicelli, then, ought not to take into account this induced electricity, since, according to his views, it is deceptive, and, in fact, if the bodies are not in motion it is not apparent. My mobile conductor issues from an aperture made in the ceiling of the room, and yet does not behave otherwise than one placed in the open air.

But I would ask of those who hold these views: Do they believe that a fixed conductor insulated between the air and the ground is not equally exposed to the twofold influence? Let them tell me how it can possibly happen that a conductor placed between two electrified bodies should not feel the influence of both.

Professor Ragona, after having furnished forth his recent Italian translation of "Mohn's Meteorology" with the description of my apparatus, and after having pointed it out also to the Spanish translator in the Annuario della Societa Met., foretells its speedy supersession by that of Thomson, which he, by some hallucination, imagines to be an apparatus with fixed conductors. The fixed or Franklin conductors have been superseded by the mobile electrometer of Peltier, and this, in turn, by the mobile conductor. No wonder, then, that to this succeeded the method of the descending jet, a variety of the mobile conductor. But I don't believe that I was mistaken when, after having studied the electrical phenomena of the ascending and descending jets, I decided in favour of the vertical conductor, which, being now well-known, I need not describe. For the last time, however, I will reply to one objection. It is said that the mobile conductor is influenced not only by the electricity of the atmosphere, but also by that of the earth. Having shown that the latter is always opposed and proportionate to that of the air in whatever way we try it, it follows that it is induced, and impotent to disturb the results sought for. Let it be supposed that the terrestrial electricity could vary in its nature and intensity independently of that of the atmosphere. I ask, what conductor, fixed or mobile, could escape the influence? It is really quite nauseous to have repeated ever the same futile difficulties without seeing the facts which annihilate them recognised. If the fixed conductor insulated with the point upwards ought to show electricity homologous to that of the air, with the point downwards and close to the earth t ought to manifest the opposite—that is, homologous to that of the earth—but this never is the case, as I have declared before, though in vain.

At first it was thought that conductors exposed in the open air became electrified by contact with the latter, and there are not wanting even eminent persons who believe that a conductor which is raised goes to collect electricity in that portion of the atmosphere through which it passes. This is why Volpicelli believes that in this conductor, at least, a part of the electricity is due to the contact. He draws his proof from seeing that the conductor, being placed for a moment in contact with the earth, quickly becomes recharged. With a conductor ending in a point the recharging should certainly take place, as, in fact, it does, but in ordinary times, at least, with a certain deliberation. With conductors without points it does not always take place, but, any way, the same phenomenon is manifested when a glass rod, charged with electricity, is put near the button of an electroscope in dry weather. Touching the button with the finger, the instrument discharges, but, removing the finger, an homologous tension is soon seen to reappear.

If a conductor in form of a rod is made to gyrate around one of its ends in a horizontal plane, the horizon being perfectly and equally free around it, there will be no sign whatever of electricity on ordinary days; but, if on one side of it is raised a wall, it will give signs of negative electricity when turned towards this; and, reduced to zero, it will give positive electricity when turned in the opposite direction. The wind, renewing the air over the conductors, does not increase their charge, nor does the air which penetrates beneath an electricised curtain that of a conductor placed there; and, finally, if part of the electricity of the mobile conductor were induced from the circumambient air, the two opposite tensions, upwards and downwards, would not be equal, as they are with a mobile conductor symmetrical at its two extremities and placed in the open air.

The mobile conductor, insulated with the necessary care, charging itself in less than 2″, either does not suffer sensible depression, or if it does so suffer, there is a means of recognising and computing it. With all other methods, not showing the losses, it is impossible to know the tension which is required. For, calling a the tension observed, x the losses, and y the true tension, we should get $x + a = y$, and x being unknown y must also remain so.

(TO BE CONTINUED.)

THE SOURCE OF SOUND IN THE TELEPHONE.

(CONTINUED FROM PAGE 5.)

IX.—ARMATURES OR DIAPHRAGMS.—An iron armature (says the *Telegraphic Journal*), no matter what form or size, when placed upon the microphone table gives out loud tones, the magnet and coil being held in the air and thus insulated; the loud tones can only be due to the armature in contact with the table.

(The sounds here are due to magnetic attractions, the loudness depending upon the best conditions for movement and rapid action in a strong magnetic field. In some following experiments this point will be elucidated.)

X.—If a copper coil without the magnet is held above these armatures, the sound is comparatively weak. An iron coil gives louder tones, due to its becoming magnetised, but both are very weak compared with those given by the side of the natural magnet. An electro-magnet with iron cores was not equal to the natural magnet, because the battery was too weak to induce a high magnetic field.

XI.—With different metals and non-conductors, such as wood, glass, gutta percha, ivory, metallic oxides, &c., &c., it was found that all conductors, if sonorous, gave out sound; but no continued trace could be found with mercury, and but slight traces with lead. All the non-conductors gave no sound whatever.

Compared with iron the following is an approximate value, being the mean of several repeated experiments:—

Iron	100	Gold	8	Carbon	2
Silver	10	Brass	7	Mercury	1
Copper	9	Cadmium	6	Wood, Glass, and	
Bronze	9	Tin	4	all non-conductors	0
Zinc	8	Lead	2		

(All the above non-magnetic conductors gave out sound by direct mechanical movement, caused by the induced currents reacting upon the magnetic field, giving repulsions where iron was attracted. This will be shown in some following experiments.)

XII.—With all the non-magnetic metals, the sound was loudest if the armature had a large surface, as a plate or sheet; the sounds were at their maximum when the magnet and coil were held over the centre of the plate, and gradually diminished when moved towards the edges.

(This shows the importance of the diaphragm form of arma-

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ture, and in the case of copper, the induced currents had a wider field for action when the magnet was held at the centre than when at its edges.)

XIII.—Each metal gave out its own particular timbre, which could be perfectly reproduced by touching it with a small strip of thin paper at the point where the centre of the magnet had been held.

(This shows that the supposed molecular sounds were really mechanical movements which could be reproduced by a feeble mechanical effort.)

XIV.—A coil of insulated copper wire placed on the table as an armature gave but feeble traces of sound if the two ends of the wires were insulated, but, on joining the wire or short circuiting the coils, loud and distinct tones were always obtained.

(This proves that the sounds are due to the re-action of induced currents in the coil upon the magnetic field.)

XV.—A coil of uncovered copper wire gave out sounds if the ends were open or closed, being then similar to a copper plate, where the currents can flow in closed circuits.

XVI.—A flat magnet gives out louder tones than an iron armature of the same form, and a still more remarkable difference is observed if a coil alone without its magnet is held above. In this case, the magnetic armature gives out tones ten times stronger than the simple iron, thus showing again the necessity for a strong magnetic field of action.

XVII.—A coil of covered iron wire gives out the same amount of sound whether the circuit be closed or open.

XVIII.—A thin iron plate armature gave out loud and clear tones; these tones were but slightly diminished by the interposition of another thin plate or plates of iron between the magnet and coil and armature. Sounds were thus obtained through fifteen interposed iron diaphragms, being then but a quarter of the original sound. If, however, the sum total of all the diaphragms could have been utilised, the total sound would have been greatly augmented.

XIX.—The coil of coloured copper wire was laid on the top of a ferrotype iron plate; the natural magnet alone held above this gave out strong tones, but if the coil was placed underneath the ferrotype, the sounds were but one-third of its previous force; this shows the advantage of having the coil direct in the magnetic field, between the magnet and its armature. In both cases, sounds were scarcely audible when the natural magnet was withdrawn: they were not one-twentieth of the original sound intensity.

(From this we cannot expect any perfect electro-magnetic telephonic arrangement which does not employ a strong magnetic field for its reactions.)

XX.—If we place on the microphone table a solid cube of iron (2 inch cube), the coil and magnet being held at a slight distance, we hear distinctly the tones, but far more feeble than in the case of a thin ferrotype of the same diameter. With the ferrotype we hear a clear metallic ring with each tone, but with the cube of iron there was no such ring, the tone being dull and muffled; in fact, the tones were those of the microphone table itself, thus indicating that the slight mechanical movement of the iron cube was transmitted to the wood, which, by its elasticity, became in reality the diaphragm or source of sound. To prove this, we found that sounds increased up to the moment when the natural magnet touched the iron, when they attained their maximum. On pressing the magnet on the iron with gradually increasing pressure, the sounds gradually faded until but slight traces were audible. On removing the pressure, sounds increased until the magnet raised the iron slightly: here was the maximum; but the instant the iron by its own weight broke the contact and thus again pressed more heavily on table, the sounds almost disappeared. Compared with the ferrotype, it was found that the latter gave out louder tones with the magnet and coil held at 3 inches distance, than upon the cube of iron at 1-16 inch distance. At ½ inch distance but feeble traces of sound could be heard in the cube, whilst the ferrotype gave out loud tones with its own peculiar metallic ring. In both cases the peculiar timbre of the cube and the ferrotype could be reproduced by touching it lightly with a thin strip of paper; thus, a slight mechanical movement would easily account for the sounds in both cases.

XXI.—A ferrotype diaphragm laid loosely on microphone table. Magnet and coil held above gave out with each sound a metallic ring exactly the same as when the same diaphragm was held to the ear and slightly touched by a piece of paper. If it was fastened on the table by its circumference, as in the telephone, we had one dominant musical note with each sound. If fastened only at its centre, the metallic ring would be prolonged long after electro magnetic sounds had ceased, it being then in a constant state of vibration from the slightest extraneous cause. If we glued or fastened this diaphragm to a thin cardboard, the metallic ring disappeared, and the tone became slightly weaker and muffled. If the diaphragm was glued throughout its surface to a similar piece of pine board 1 inch thick, the tones became very weak, resembling the cube of iron, and the tone was no longer that of iron, but that of wood.

(This shows that the tones could not be due to any particular molecular movement in the iron plate, but that the tone or timbre is due to the body actually in movement, as the metallic tones of iron can be gradually masked, partaking of the intermediate tones of iron and wood, until, by increasing the thickness of wood, the metallic tones are entirely lost by the predominance of those of the wood.)

XXII.—The surface of a diaphragm of cardboard had glued to it parallel layers of thin uncovered iron wire; this diaphragm gave out the tones of cardboard either on the microphone table, or if it replaced the ferrotype in an actual telephone; in both cases the tone was comparatively weak, compared with the same amount of iron and surface in the ferrotype, a result due to the want of elasticity in the cardboard. The same iron wire glued to a thin glass plate gave out clear, sharp tones, but the tone was that of glass, and not that of iron. From this we should judge that the varnish on ferrotype serves an excellent purpose in slightly muffling the metallic ring of the iron plate.

XXIII.—In order to see if we could render these movements of the diaphragm visible to the eye or touch, a thick tin plate diaphragm was placed in a telephone in direct circuit of the first transmitting microphonic circuit. The sounds were very clear and loud, but no movement whatever of the diaphragm could be perceived by the eye or touch. A very thin charcoal iron plate was now used; the tones were louder than before, but still no visible movement. This plate then had a small narrow segment cut out of it from the circumference to the centre. The sound was slightly diminished, but strong movements were visible both to eye and touch; by placing the finger on the divided portion not only could every beat of the clock be perfectly felt, but its peculiar timbre in a slight degree recognised.

(Here we have transformed a sound which in the first place gave out no visible movement, and which might from this be supposed to be due to some molecular motions, into one of direct mechanical movement recognisable by touch, and where molecular action is not at all necessary to its explanation.)

XXIV.—Knowing that each diaphragm in a telephone has its own dominant tone, which accompanies all sounds emitted, the diaphragm was divided into two slightly unequal portions. Clear loud tones were then produced as before, but they were accompanied with two dominant tones—in fact, a chord, due to the different dominant tones of each segment of diaphragm. By chance they happened to be an exact fifth, and the word "telephone," like all other words transmitted to it, was accompanied by the dominant chord, and I am convinced that by proper arrangements four segments reproducing the whole chord could have been obtained.

ELECTRIC AND GAS LIGHT AT BILLINGSGATE.

On Monday night the old-fashioned method of lighting by gas and one form of the electric light were subjected to a species of competitive examination at New Billingsgate Market. As a theatre for the display of the power of the electric light in illuminating large spaces few spots could have been better chosen. Requiring light inside and out, New Billingsgate is singularly well adapted to display the all-round every-night power of any system of illumination. Up to the present, gas lights disposed on a temporary plan have supplied the wants of the market fairly well, but the fame of the electric system as practised in the Avenue de l'Opéra at Paris has induced the Corporation of the City of London to test its power on some large areas in the metropolis. This resolution was not arrived at without due deliberation. Encouraged by the success achieved by the new illumination, the Markets Committee requested their chairman, Mr. Rudkin, accompanied by Mr. Henry Greene, the chairman of the Billingsgate Sub-Market Committee, and Mr. Joseph Beck, F.R.A.S., to proceed as a deputation of the Markets Committee to Paris for the purpose of seeing and reporting on the efficiency of electric lighting as practised in that city. The result of this visit was the experiment, prevented a few days since by an untoward accident to the Gramme electrical machine, but performed last night before a large body of spectators.

The general conduct of the experiment was confided to the Société Générale d'Electricité of Paris, and it is, therefore, needless to add that the Jablochkoff "candle," as it is oddly called, was the method employed. So many descriptions of this celebrated invention have already been presented to the public that no detailed account of it is necessary. It will suffice to premise that the three constituents of electric illumination are—firstly, the steam-engine to drive the induction engine (the generator of

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electricity); secondly, the last-named engine itself; and, thirdly, the carbon points or pencils, as they are called, their arrangement with reference to each other, and to the current necessary to excite them to action. The steam engine employed being merely a driver, may serve equally well for any system of electric illumination, but from this point some divergence is found between the various methods. The machinery in operation last night was Robey's Electric Light Fixed Engine, driving the well-known Duplex Gramme apparatus which generates the electricity. The latter is conveyed by wires leading from the machines to the commutators, of which more presently, and from thence direct to the lamps, candles, or points, as they may be called. It is in the construction and working of these that the Jablochkoff system differs so widely from all others. Every one is familiar with the electric lamp of lecturers in which a stream of electricity is conducted through two points of carbon nearly touching each other. These are at first brought into contact, and, being then separated, what is called an electrical arc or link of communication is formed by the current, and it is this arc which constitutes the illuminating power. The Jablochkoff candle differs widely from every other contrivance for securing the equal consumption of the carbon points or wicks. Every trick of clockwork had been employed to compensate for the unequal consumption of the points when M. Jablochkoff discovered that by putting two carbon rods or pencils side by side, separated by a non-conductor throughout their length except at the top, where they are joined for the purpose of making the first connection necessary to the establishment of an electrical current, and by reversing the current several times per minute from one to the other, he would ensure their equable consumption. This result of thought and experiment has been visible in Paris for several months past, and was presented to the public of London on a large scale last night. The now celebrated "candle" which is fixed in the burners or chandeliers is an instrument composed of two straight rods of carbon (compressed coke is the variety used), separated, except at the top, where a temporary and easily combustible bridge connects them, by a broad white line of china clay or plaster of Paris. The candles thus made are about nine inches high, half an inch wide by three-sixteenths of an inch thick, and are fixed on two small brass tubes, so that, when placed in position in the lamp, they are brought in direct contact with the electric wires, which are conducted from the machine in which the electricity has been generated. Each lamp has four of these candles, and each candle is estimated to burn an hour and a half, when by the action of a switch a fresh candle is brought into action, and that again at the end of an hour and a half is replaced by another, so that the whole four candles are calculated to burn six hours, or, perhaps, a little more. Up to the present time this change of candles has to be effected by an attendant periodically moving the switch, and this is one of the difficulties which beset the Jablochkoff candle. In addition to the cost of the candles, estimated at sevenpence-halfpenny each, there is involved, under present conditions, the manual labour of looking after the lamps, almost recalling the old times of the oil *réverbère*. Each lamp is surmounted by a handsome opaline globe, about seventeen inches in diameter. Unfortunately, the use of this globe takes away from forty to forty-five per cent. of the light; but there is no choice between using some medium of this kind and enduring the piercing rays of the naked lamp, whereas the light, as seen when shaded, is pure and clear, and it is thought will be well suited to the requirements of a market which, throughout the winter months, has entirely to be carried on with the aid of artificial light during all its busiest hours, commencing at five o'clock each morning.

A large number of invited guests having assembled at New Billingsgate Market, shortly after six o'clock M. Berly, the engineer of the Société Générale d'Electricité, set his apparatus in motion, and Billingsgate was for the first time illuminated by the aid of electricity. It had been considered that sufficient light would be obtained from sixteen lamps, each reckoned equal to one thousand sperm candles, if not veiled by the opalescent globe. Nine of these globes were distributed over the ground floor, an area of nearly forty thousand square feet; two threw a bright light over the river, and the remainder were reserved for the upper storey—the dried fish market—and for the Thames-street side of the building. No sooner was the new light turned on than it was freely criticised. It became at once apparent that its greatest strength lay in the largest space, the two lights on the wharf illuminating it and a large area of the river almost *a giorno*. It was quite easy to read the names of the consignees of a mountain of fish boxes piled in a neighbouring lighter, and the effect of the light flung on the river was nothing short of beautiful. More practical considerations influenced those discussing the projected improvement inside, many practiced salesmen insisting on their preference for gas. Little fault was found with the effect of the Jablochkoff light, so far as purity and diffusion were concerned, but either from the remote position of the burners or the smallness of their number their particular application to the necessities of fish salesmen and buyers was eagerly disputed. It is the custom of a fish salesman to stand at the head of his "bench," and as each box or basket is brought by his assistant to cry out for buyers of the particular class of fish it may contain, whether sole or "prime," as fine flat fish is called, or "offal," a term signifying at Billingsgate not refuse, but lower-class fish, such as haddock. As the box is placed before him buyers crowd around it, examine and bid for it as at any other auction, and this scene was rehearsed several times last evening in order to test the capacity of the new light. The result, owing to the position of the burners, could hardly be satisfactory, and it was then thought well to cut off the electricity and fall back upon the gaslight, which all sticklers for good old fashions proclaimed to be infinitely superior for their purpose. This verdict, however, can hardly be deemed conclusive, inasmuch as the electric lamps, either from being worked with entirely new gear or from some other cause, shone with far less brilliancy than those in the Avenue de l'Opéra, and exhibited a tendency to fluctuate not observable in the latter. There is apparently no manner of doubt that the salesmen of Billingsgate prefer a close if a coarse light to soft radience diffused generally over the building, but this circumstance militates in no kind of way against the employment of the electric light for the illumination of large areas. The cost of that employed last night was stated to be about equivalent to that of the gas hitherto used—some eight hundred pounds per annum; no very large sum for the lighting of an immense building. How far in this respect the avowedly costly Jablochkoff candle will compare with the Rapieff system introduced into this country by Mr. John Hollingshead,* and the more recently exhibited method of M. Werdermann, which, needing no opaline globe, saves thereby much lighting power, remains to be decided. For the present, it is sufficient to record that the Jablochkoff system, after standing the test of practical experience in Paris, is now on its trial on a large scale in London, as it is intended to light Billingsgate Market with it until further notice.—*Daily News.*

[* The Lontin system is that which was introduced by the gentleman whose name is here mentioned.—Ed. *E.*]

BOMBAY GAS COMPANY.

The half-yearly general meeting of the shareholders of the Bombay Gas Company was held at the Cannon-street Terminus Hotel on Thursday, the 21st inst., under the presidency of Mr. D. T. Evans, who, in referring to the electric light, said he had no doubt it was in every gas shareholder's mind at that moment. He had seen it in actual operation in Paris, and they had all read Mr. Sugg's report and Mr. Livesy's letter as to the practical application of electric lighting. A meeting of delegates from various provincial gas companies was recently held at the Westminster Palace Hotel, to consider whether it might not be advisable to go to Parliament—each company separately or all together—for some comprehensive measure to obtain power for existing gas companies to light by electricity. Of course, the great and material question was, Can electricity be economically employed? The initial cost for motive power was so great, in addition to the pay of the engineers and attendants to keep up the candles and carbons, that it would deter persons of small means from using it. A personal friend of his, Mr. Michael, Q.C., who was for many years chairman of the Swansea Gas Company, a gentleman who practised in Parliament, and had had very large experience in matters of gas legislation, made the following observations on the occasion with reference to the cost:—"Now, the cost at the present time in Paris of burning the carbon alone, the cost of its conduction to the place of burning, and all the expenses incident to the production of the light, came to five-sixths of a penny per hour, and to burn gas in London would cost exactly one halfpenny to give the same amount of light. That was the mere candle that was burned, without any of the costs incident to the production of the electricity. The capital employed, and all the incidental expenses connected with the production of the electric light, were very nearly equal to double the present cost of gas. This at once removed the possibility, unless something better were produced, of their having anything to fear from the introduction of the electric light." Further on, Mr. Michael remarked: "The important question was, What should be the attitude of the gas companies, not as affecting the value of their property, but as affecting the estimation of the value of their property? And it was quite true that the two things sometimes, unfortunately, went together. He held that their property was not in the slightest degree deteriorated by what had been done, or could be done." It was, the Chairman continued, a very

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remarkable fact that the best experts could not get at the actual cost of the production of the electric light. That was still kept in the background. Mr. Michael also in his speech said that "he had heard that morning that the whole of the lights in the Place de l'Etoile had been removed, and he had also heard from the same correspondent that the whole of the lights would be removed from the Place de l'Opéra.—Mr. Northover, a shareholder, said that he knew that the contract was out, and the Municipality were not disposed to continue it. It was only on the understanding that the Compagnie Générale d'Electricité would charge a lower price that the contract was renewed, because they felt that the removal of the lights at present would be rather fatal to their shares and to the success of the company. If there was any comfort to be derived by the shareholders from the introduction of the electric light, it would be found in the direction of the residuals. As a rule, the Press were adverse to gas; but if, on the other hand, any one wrote to a paper pointing out any defect in the electric light, no notice was taken of the letter. The other day the writer of the Money Article in *The Times* alluded to the question of cost, and it called forth the next day a letter from the secretary of the National Electric Light Corporation, who said all recognised authorities admitted that gas was much dearer than electricity. He quoted M. Fontaine's book, page 167, to show that it was in one instance 33 per cent. cheaper than gas, but he did not mention the price of the gas on which the calculation was made. As a matter of fact, it was in Paris 8*s.* per 1,000 cubic feet, while in London the price was only 3*s.* 6*d.* Such statements were simply misleading the public. There was not an electric company in existence who would name a price for each burner. He knew a firm in London which wanted to have their house lighted by electricity as an advertisement. They applied to a person in Birmingham, but, though the order had been given more than two months since, the lighting had not yet taken place. At first, they were to have 16 lights, then eight, now it was decided to have four or five, but it was very doubtful if it would be accomplished at all. He, however, thought that at some future time electricity would supersede gas as a means of lighting squares and large open spaces. The object of the formation of the electricity companies was, he said, really to sell their patent rights; but, if the patentees were so conscious of the superiority of their systems, why did they not work them and reap the profit themselves? He knew a gentleman who used the electric light for three weeks in a continental hotel, and when he came back to England he complained that his glasses would not do at all. Their power had to be augmented something like 70 per cent., and he was told that if he continued to use the electric light he might, in the end, lose his eyesight altogether.—Mr. Penny said that some little time ago he attended an exhibition of the electric light by Mr. Werdermann, and what he then saw led him to the conclusion that, unless some means were discovered of obtaining electricity at less cost than at present, it would never become the light of the future. It was not, he said, a light which any man could put about his house and leave in the care of his servants. There could be no store of electricity, and the instant the engine ceased to work from any cause or accident all the light would be gone. These two points alone convinced him that gas shareholders had no need to trouble themselves very much.—Mr. Henry Palfrey Stephenson, a director, said that one of the shareholders had asked whether the Crystal Palace Company were going to use the electric light. They had intended to do so some weeks ago, but some difficulty had arisen because a very heavy preliminary outlay was necessary. For five lights in the Crystal Palace an expenditure considerably over 1,000*l.* was necessary. [A shareholder: I heard that it was 1,340*l.*] He had since heard that arrangements had been made for lighting the palace by means of electricity. He thought there had been a great deal too much said about the electric light. Althought it might come into operation under certain circumstances, and in certain situations, as at present developed, it was, he said, totally inapplicable to private light. No doubt, people would say, "But, look at the progress of science." He was one who bowed down to science, and would not be suprised at anything it might do in the future. He was quite ready to admit that at some distant day electric lighting might become general; but it might be that at some remote period men might fly, and that telescopes might be so improved as to enable us to see a fly on the back of a cow in the moon! All these things might be possible, but they were a long way off.

THE WERDERMANN LIGHT.—We understand that sanction has been given for a trial of this light in the open space before the Mansion House. This is an admirable position for such a trial, and will give the English public a fairer idea of what can be done in open spaces by the electric light than any experiments which have yet been made.

RECENT PATENTS.

1155. TELEGRAPHS, *R. Theiler, J. E. Wright, and M. Theiler.—Dated 23rd March*, 1878. 6*d.*

The pressure of air, gas, or of a liquid, is used upon a yielding or movable body for the purpose of assisting or increasing the mechanical effect of the line current in telegraphic receiving instruments. Instead of sending currents of unequal duration equally spaced, the currents are of equal duration, and are spaced unequally. For this purpose the rocking lever is of the usual form, and its motion limited in the usual way by a contact stud in front, and one at the back. This motion is magnified by additional leverage, and transmitted to a contact maker to which a click and guiding piece are attached, which allowed it to move in a certain line when going downwards, and force it to move in another line when going back, so as to rub against one contact in going down and against a different one going up. But before going from one to the other it touches neither of the two, and the circuit is consequently broken by suitable connections with the lines, earth, and battery.

1370. TELEPHONES, *A. Paris.—Dated 6th April*, 1878. 6*d.*

For signalling at each station an electric bell is automatically interlined in the conducting wire, while at the same time the transformation of the speaking wires into line wires for signalling is accomplished by the telephone itself, when the latter is placed in a cup on the apparatus or suspended on a hook. The cup or the hook is in connection with disconnecting appliance, and is by taking up the instrument depressed or turned by its weight, whereby the connection of the line wires with the signalling apparatus is established, the connection of the former with the telephone being at the same time interrupted.

1375. SIGNALLING ON RAILWAYS, *T. T. Powell.—Dated 6th April*, 1878. 6*d.*

A single insulated bar of metal is placed in the centre of the four-foot way, and a trailing runner is placed under the engine and guard's brake van, and is in constant contact with the insulated bar. Other drags are fixed beneath each carriage, and are in connection with a handle placed in each compartment, and also with the draw-bar of the carriage, so that when required to signal, a passenger, by pulling the handle drops the runner on to the bar, and at the same time causes a small signal to project from the carriage, and thus indicate the exact place that the signal originates from. In the same way, should a carriage break away from the other part of the train, the strain being taken off the draw-bar, will also release the runner and allow it to drop on the insulated bar. This bar is connected at each end by wires to suitable signalling instruments in the block signal cabins. Batteries of suitable strength are placed on the engine van, and are connected by insulated wires with the trailing drags or runners.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES NOV. 27.		BUSINESS DONE WEEK ENDING NOV. 27. Highest.		Lowest.	
Anglo-American	59½,	¾	60		59½	
Do. "B"	85¼,	6¼	86½		85¼	
Do. "A"	34½,	5½	35½		31½	
Brazilian	6⅛,	⅛	6⅛		6⅛	
Cuba	8,	¼	8¼		—	
Do. Ten per Cent. Preference	15½,	¾	—		—	
Direct Spanish	2,	¼	—		—	
Do. Ten per Cent. Preference	9¾,	10½	10½		10	
Direct United States	12½,	½	12⅝		12½	
Eastern	7 7-16,	9-16	7⅞		7 5-16	
Do. Six per Cent. Debenture	103,	106	—		—	
Do. Five per Cent. do.	99,	101	—		—	
Do. Six per Cent. Preference	10¾,	11½	11½		10⅞	
Eastern Extension	7⅛,	¼	7⅛		7⅛	
Do. Six per Cent. Debenture	104,	107	105⅝		104⅜	
German Union	8,	⅜	—		—	
Globe Telegraph and Trust	4 15-16,	5 1-16	5 1-16		4 15-16	
Do. Six per Cent. Preference	10½,	⅜	10⅜		10⅜	
Great Northern	7⅞,	8⅛	8		—	
Indo-European	19¾,	20½	20		—	
Mediterranean Extension	2⅜,	3	2⅜		—	
Do. Eight per Cent. Preference	8¾,	9¼	—		—	
Reuter's	9¼,	10⅛	—		—	
Submarine	215,	220	218		217	
West India and Panama	1⅞,	2	2		1⅞	
Do. Six per Cent. Preference	8,	¼	8⅛		8	
Western and Brazilian	2¾,	3	—		—	
West. Union Seven per Cent. 1st Mortgage	112,	115	—		—	
Do. Six per Cent. Sterling	100,	102	—		—	

TRAFFIC RECEIPTS FOR OCTOBER, 1878.

COMPANIES.	October, 1878. £	October, 1877. £	Increase. £	Decrease. £
Anglo-American Telegraph Company	54,150	49,510	4,640	—
Brazilian Submarine Company	13,138	11,387	1,751	—
Cuba Submarine Company	2,800 estd.	2,933	—	133
Direct Spanish Telegraph Company	1,106	914	92	—
Direct United States Telegraph Company	18,050 estd.	13,480	4,570	—
Eastern Extension Telegraph Company	23,393	21,388	2,005	—
Eastern Telegraph Company	41,678	37,402	4,276	—
Great Northern Telegraph Company	19,737	—	—	—
Submarine Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	10,290	—	—
West Coast of America Telegraph Company	—	—	—	—
West India Telegraph Company	—	—	—	—

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NOTES.

THE ASTATIC NEEDLE.—This system was the invention of an Italian philosopher, the Chevalier Leopold Nobili.

GALVANOMETERS.—Professor Schweigger was the first to use an instrument which bore any appearance to a galvanometer. He used a compass box, with a copper wire coiled several times round it, whose convolutions were parallel to the meridian line of the card.

MR. EDISON AND THE ELECTRIC LIGHT.—A correspondent writes:—"We hear, from a source which is usually reliable, that Mr. Edison has not yet—or, at least, had not three weeks ago—lodged any patent specifications in his own country for electric lighting! This is very extraordinary, if true."

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of November was 2,467, against 2,298 messages in the corresponding month of last year. The traffic receipts for the month of September, estimated at 2,600*l.*, realised 2,463*l.*

RESISTANCE OF THE ELECTRIC ARC.—The following data relate to one of the Suisse lamps exhibited, Dec. 4, in action at the Society of Arts. The resistance of the lamp and carbons was 3 ohms, that of the Gramme machine was 1·7 ohms, and the resistance of the arc between the carbon points was found to vary between ·9 and 1·7 ohms.

OBJECTION TO EDISON'S PATENT.—A notice of objection to the grant of Letters Patent to Mr. Edison for "Improvements in the method of and means for developing electric currents and lighting by Electricity" was filed on Tuesday, Dec. 3, at the Great Seal Patent Office, by Messrs. Herbert and Co., agents for Mr. J. H. Russell. The ground of the objection is that Mr. Edison "is not the true and first inventor." The case will be heard by the Solicitor-General in chambers, probably before Christmas.

JERSEY.—Cable communication between Jersey and England is interrupted. The interruption is supposed to be caused by a rupture of the deep sea portion of the cable lying between Guernsey and the English coast. It has not yet been ascertained at what portion of the line the breakage has occurred. Pending repairs to the cable, messages from England will be conveyed to Guernsey by mail packet and wired thence to this island; messages for England will be wired to Guernsey and picked up there by packet for conveyance to Portland, where they will be despatched by telegraph.

A COOL HAND.—A querist in a contemporary recently asked one of his fellow readers to describe, for his edification, *all* forms of battery, of course giving materials used, size, price, electrical value, and other similar information. We—who may be supposed to have read of a few batteries—should hardly hesitate to tell such a questioner that he asks for the impossible. No man living knows the details of *all* the forms of battery, and, if such an one did live, doubtless he would be accommodated with the whole street for his especial benefit whenever he chanced to have a desire to interview the weather.

ELECTRICITY AND EARTHQUAKES.—Sturgeon, whose name is most unaccountably overlooked by those who are popularly deemed to have some knowledge of electrical subjects, wrote in 1836:—"If, then, electro-momenta, capable of producing violent shocks and vivid sparks, can be produced by a few hundreds of feet of thin copper wire, what is it that might be expected from the electro-momenta of nature, arising from currents of many miles in extent, kept in motion either by heat, saline solutions, or by other causes, amongst the metalline strata below the surface of the earth? A sudden disruption of the circuit would insure the blow, and an earthquake might be the result."

THE EDISON LIGHT.—Mr. Edison announces that he has perfected a machine for measuring the current used in the electric light. It consists of an apparatus placed in every house lighted by electricity, which registers the quantity of electricity consumed, and uses for the purpose the one-thousandth part of the quantity consumed in the building. Mr. Edison declares that his invention of the light, including the arrangement for counteracting loss in subdivision is now completed. His experiments at present are directed to reducing the cost. He has, he says, already brought this decidedly below the cost of gas, and as soon as the minimum is reached will make the results public.—*Daily News Telegram.*

"TAKE NOTICE: A HUMBLE VOICE FROM AMERICA."—The signature appended to the verses bearing this title, printed in our issue of the 9th ult., has given rise to what in more senses than one is a funny mistake. The lines appear to have been understood and relished in many quarters, but the signature, which stamped them as a jest, has been taken by several intelligent editors in real earnest, Mr. F. Unney, contributor to *The Electrician*, being credited with the production! A Mr. L. E. Fant, of Boston, U.S., once pestered the proprietor of a New York Hotel for several days by wire demanding the trunk which, in spite of denials, he declared he had left behind him; and it was not until the whole batch of telegrams appeared in the newspapers that the hotel keeper awoke to the meaning of the elephantine hoax. This time it is the newspapers who are a trifle dull.

THE MULTIPLYING SOUND RECORDER.—Under this title a correspondent of a contemporary furnishes the particulars of his mechanical device for graphically reproducing an enlarged record of the vibrations of a diaphragm. We should not have referred to it but that the author introduces it with a flourish about his "inventive energy" and "scientific research" as something on a par with those of "Wheatstone, Faraday, and Helmholtz." The fact is, the thing has been done in a much simpler and more reliable way by means of the logograph, which was exhibited by Mr. W. H. Barlow, F.R.S., V.P. Soc. C.E., before the Society of Telegraph Engineers in February last. His modest and unpretending account of it is published at page 65, No. XXI., of that society's Journal. As to the alleged discovery made by the correspondent before referred to, namely, that the vibrations are not all in one plane, nobody, so far as we know, has asserted that they were.

AMALGAMATED ZINC.—The first account we have of amalgamated zinc being employed in Voltaic arrangements is in Sir Humphrey Davy's Bakerian Lecture for 1826, where we read that "Zinc, in amalgamation with mercury, is positive

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with respect to pure zinc." Mr. Kemp, of Edinburgh, seems to have been the first person who employed amalgamated zinc and copper in the regular construction of apparatus. He says, in the *Edin. Phil. Journal* for Dec., 1826, the great expense of every form of galvanic apparatus that has hitherto been offered to the scientific world has prevented full investigation, and goes on to describe the apparatus he had devised to obviate the great and useless consumption of zinc. Since the time of Kemp—fifty years ago—what strides have been made! It is exceedingly interesting to read the experiments made, even in the seemingly trivial matter of amalgamated zinc, of such giants as Daniell, Faraday, and Sturgeon.

The Telephone in America.—The Bell Telephone Company has placed on the market about 20,000 telephones, and is now making over 400 per week. Telephones were first used only on private lines; but, in the spring of 1877, Mr. Coy, of New Haven, Agent of the Bell Telephone Company, devised the exchange system. Lines radiate from a central office to the houses and offices of the subscribers; and subscribers put in connection through the central office with any other subscriber can at pleasure carry on private conversation. The great advantages of such a system are evident on slight examination. It has already been introduced into all the principal cities of the country, and is destined to produce a great change in the method of doing business in cities, as the telegraph has between more distant points. Many private lines of ten, fifteen, and twenty miles in length are already in operation, and there seems to be no practical difficulty in connecting, by telephone lines, places several hundred miles apart. The highest award, with the grand prize, at the Paris Exhibition was given to Professor Bell as the inventor of the articulating telephone.

On a Series of Magnetic Compounds having the Formula $M''Fe_2O_4$.—Of the possible compounds of ferric oxide with the basic oxides isomorphous with ferrous oxide, only two, $MgFe_2O_4$, prepared by Deville, and $ZnFe_2O_4$, by Ebelman, both produced at high temperatures, are known. List has undertaken to prepare these compounds in the wet way. A ferric chloride solution as nearly neutral as possible was precipitated with excess of lime water or of calcium saccharate, the bright leather brown precipitate washed with lime water, filtered, dried, and ignited. A dark brown friable powder, having the composition $CaFe_2O_4$, was obtained, which was strongly attracted by the magnet. Barium ferric oxide, obtained similarly, had similar properties. The magnesium compounded, prepared either by adding magnesia to a neutral solution of ferric chloride, or by adding potassium or sodium hydrate to mixed solution of ferric chloride and magnesium sulphate, is a cinnamon brown powder strongly magnetic. Manganous, zinc, nickelous, cuprous and lead oxides, yielded like magnetic compounds. Even potassium and sodium oxides, ignited with ferric oxide, yield a compound attracted by the magnet.

Edison's Sonorous Voltameter.—The sonorous or bubble voltameter consists of an electrolytic cell, with two electrodes, one in free contact with a standard decomposable solution, and the other completely insulated by vulcanised rubber, except two small apertures, one of which gives the solution free access to the insulated electrode, and the other allows the escape of bubbles of hydrogen as they are evolved by electrolysis. With a given current and a given resistance, a bubble is obtained each second, which is seen at the moment of rising, and which, at the same time, gives a sound when it reaches the air. The resistance may be reduced, so as to give one bubble in one, five, ten, or fifty seconds, or in as many hours. I have compared this instrument with the ordinary voltameter, and find it much more accurate. By the use of a very small insulated electrode, and but one aperture, through which both the gas and water current must pass, great increase of resistance takes place at the moment when the bubble is forming; and, just before it rises, a sounder magnet included within the battery circuit opens, closing again when the bubble escapes, thus allowing, by means of a Morse register, the time of each bubble to be recorded automatically. This apparatus, when properly made, will be found very reliable and useful in some kinds of work, such as measuring the electro-motive force of batteries, &c. By shunting the voltameter, and using a recorder, it becomes a measurer not only of the current passing at the time, but also of that which has passed through a circuit from any source during a given interval.—*Amer. Assoc. for Advancement of Science.*

Receiving Telephones.—Mr. G. Johnstone Stoney describes, in *Nature*, the following experiments which he has made, but, being prevented from continuing his investigation, he hopes others will take up the question:—"In one experiment a spiral wire (I used German silver, but it may be of any material) was wound closely so that the spires were in contact, or nearly so. One end of the spiral was fixed and the other end attached by a thread to the middle of a small parchment drum head, such as is sold by the toy makers for thread telephones. A slight tension was put on the thread to draw the spires of wire slightly asunder. The spiral wire was then made part of a circuit, including one or two cells of Grove's battery and a line wire going to another room. By this apparatus such sounds as the scraping on a file were satisfactorily heard, although the spiral was only one coil of about an inch long. It will be observed that in this arrangement there are no magnets; the whole effect is produced by the varying induction of the current upon itself. The apparatus could obviously be rendered more efficient by using a longer spiral, or a coil consisting of a number of concentric spirals not quite in contact, so as to allow small motions to exist. The induction might be still farther increased by using a spiral of two wires, so that a powerful local current might be kept up in the alternate spires, while the varying line current is passing through the intermediate ones. Another improvement would consist in using iron wire wound in a sufficiently loose coil. The self-magnetisation of this coil would co-operate with the electric induction to heighten the effect. In the other arrangement an iron or steel spiral (in my experiment it was an ordinary steel spiral spring, of which the spires lay close) was placed inside a coil of copper wire in circuit with a battery and the line. The spiral, as before, was fixed at one end, and kept slightly stretched by a string connecting its other end to a drum head. In this arrangement no current passes through the spiral, but it is the core of an electro-magnet, and becomes magnetised in a degree which changes with the alterations in the intensity of the line current. This causes the spires to attract one another with varying intensity, and the tremulous motion so produced is propagated by the string to the parchment. By this arrangement singing, whistling, &c., were heard when a Reiss transmitter was used. Probably a soft iron coil would have been better than the steel spring I used, and the apparatus is susceptible of other obvious improvements which would add to its sensitiveness.

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THE DE MERITENS MAGNETO-ELECTRIC MACHINE.

Many of the visitors to the late Exhibition at Paris, who took an interest in the electric light, looked in vain for a new machine which was said to surpass all previous inventions in economy of production of the current. The machine was not in the Exhibition, and a long journey across Paris had to be performed by any one who wished to see it. During a short visit to Paris we had long conversations with M. du Moncel, and afterwards with M. de Méritens, as to the merits of the new machine. M. du Moncel about that time contributed an article on the subject to our Parisian contemporary *L'Electricité*, and we understood that a pamphlet giving the details of experiments would shortly be issued. More recently another article has been given in *L'Electricité*, and we have not hesitated to translate both articles for the benefit of our readers.

"The commercial and industrial market which the electric light has opened for electro-magnetic induction machines has stimulated on all sides researches and improvements which have materially forwarded the problem of lighting by electricity.

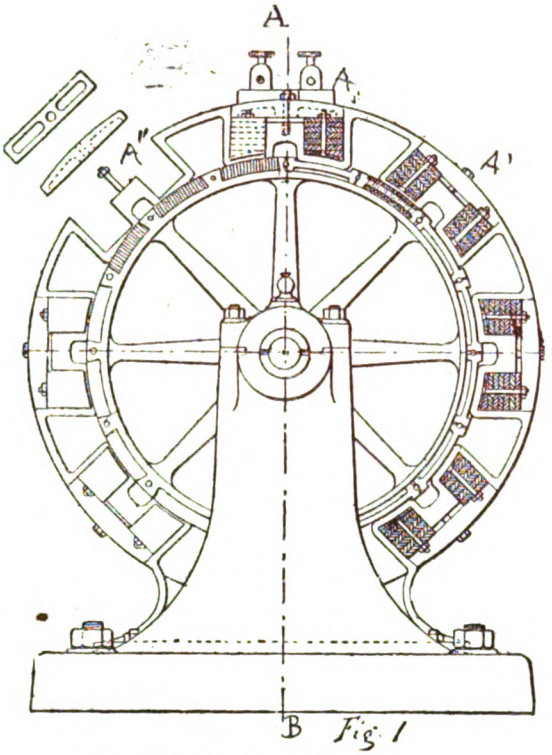

Fig. 1

Vertical elevation of machine.

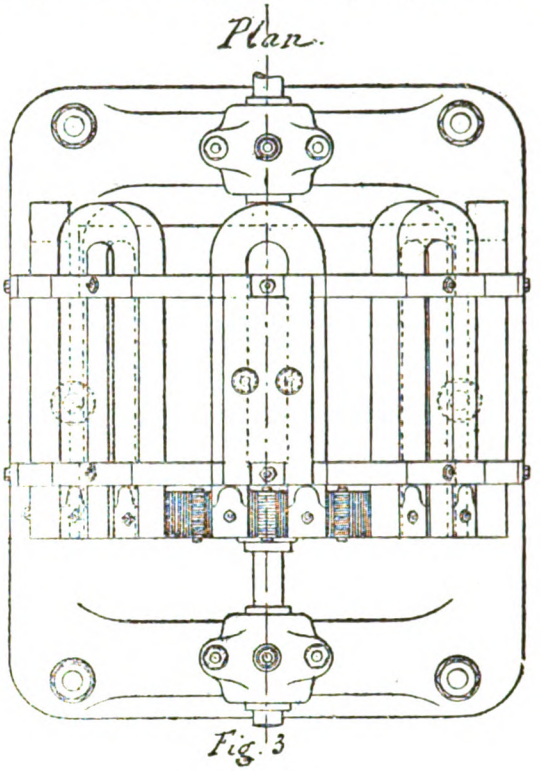

Fig. 3

Surface view.

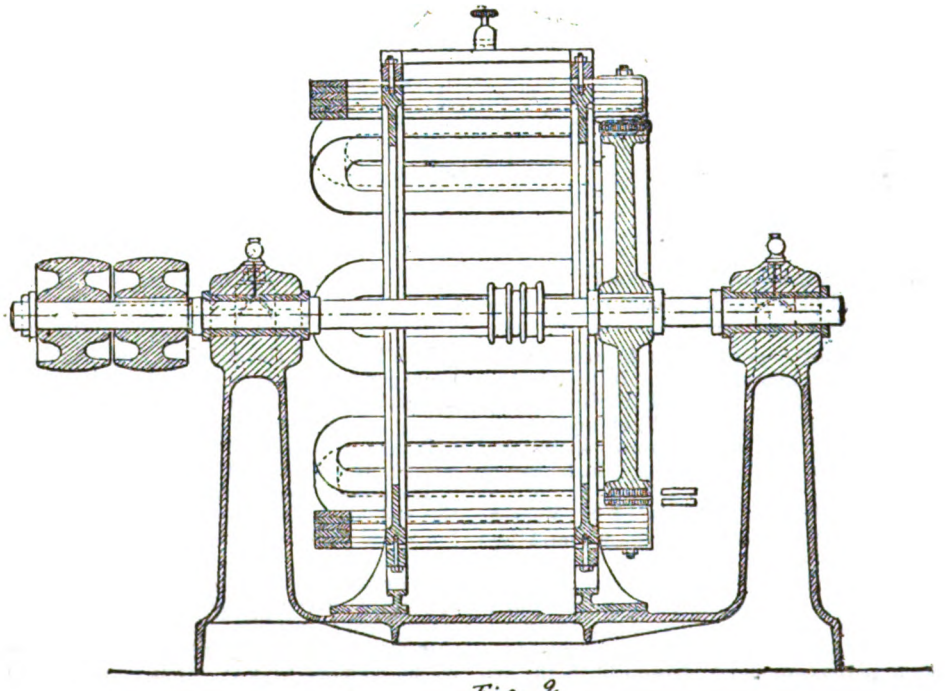
Fig. 2

Vertical section.

Everyone now knows the splendid machines which MM. Siemens, Gramme, and Lontin, have made, and would imagine, on seeing them, that they could hardly be improved upon.

Nevertheless, we think that the definite solution of the problem has not yet been arrived at, and that, in all probability, before long something further will be discovered. Meanwhile, the machine which M. de Méritens has just constructed is a consi-

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derable step on the way, and I am satisfied that this machine, which has already astonished those who have seen it work, has not yet attained the limits of its power.

We who have followed from their birth the progress of these machines, who have ourselves helped towards their earlier improvements, see with true pleasure the gradual advance of this industry, whose birth-place may be said to be in France. But, whilst admiring, let us not forget that it is to the Alliance Company, and its ingenious engineer, M. Van Malderen, that we owe this wonderful application of electricity. We think, therefore, that it will interest our readers to give a short account of these machines.

In 1855 M. Nollet, a Belgian maker, constructed for electro deposition large magneto-electric machines on the Clarke principle, which gave such important results as to originate the formation of a company, who endeavoured by means of these to extract gas from water. This notion was impracticable, but precisely on that account did it find followers, and this was the company which, under the name of the Alliance, established in 1855, in the buildings contiguous to the Hôtel des Invalides, the first great magneto-electric machines known in Europe.

Naturally, the results obtained were very poor, and in 1856 the company was obliged to liquidate.

It was reorganised again in 1856, and, after naming M. Berlioz as its director, it endeavoured to turn to account the large amount of material it had manufactured. It was at this time that I was consulted, and pointed out to M. Berlioz the use which might be made of it for the electric light and electro deposition; but, to accomplish this, many improvements had to be made in the machines, towards which every electrician of the time lent a helping hand.

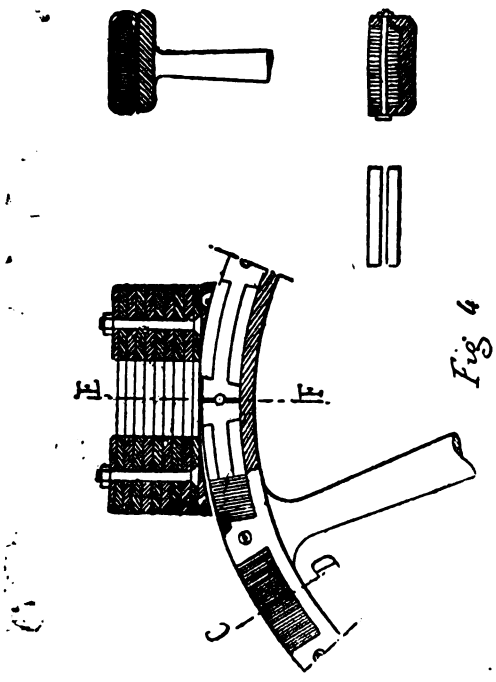

Fig. 4

Details of construction, with accompanying sections E F and C D, showing the adjustment and position of the pieces forming the wheel.

Amongst the improvements suggested was one of M. Masson, then Professor of Physics at the Ecole Centrale, whom I had prevailed upon to look at the machines, which immediately doubled the results obtainable. This was to do away with the commutator which had hitherto been used in all these machines. These improvements being all excellently carried out by M. J. Van Malderer, together with those effected by himself, caused the machines to arrive at a perfection never dreamt of in the original, and which one might well believe could not be surpassed. Then it was that they thought of turning them to account for lighting lighthouses and marking the course of vessels; experiments were next made in conjunction with MM. Reynaud and Degrand, and early, in 1863, the lighthouses of Hève were furnished with this light.

At the same time, experiments were made as to its utility in navigation, which were not at first as successful as was expected, chiefly on account of the ill will encountered at the hands of the Navy, but which later on furnished results of great importance. It was France who was foremost in achieving this double result, as she has been since in applying it to public purposes. But we must say that it is to the Alliance Company and the courageous initiative taken by its intelligent director, M. Berlioz, that the world owes these admirable electrical inventions.

This tribute of praise rendered to a company whose luck did not second its efforts, let us pass on to examine the progress made in the later times succeeding it.

The Alliance was a magneto-electric machine, that is to say, one formed of permanent magnets and induction coils. In its last model it employed 48 magnets, and 16 induction coils each strengthened by 4 relays; it gave alternate reversed currents, and could supply three Jablochkoff lights; it had a motive power equal to three horses, and attained a speed of 400 revolutions per minute. The heat produced was tremendous, and the light given very steady.

Under altogether exceptional conditions, this result has been very much increased, and, indeed, they talk of a machine able to supply 6 lights, but ordinary machines do not give such results. The machine of which we shall presently speak was capable, with only 8 magnets, of the same size as those of the Alliance, of lighting 3 or 4 Jablochkoff lights, and also gave reversed currents, which was with reason regarded as an element in favour of its public use.

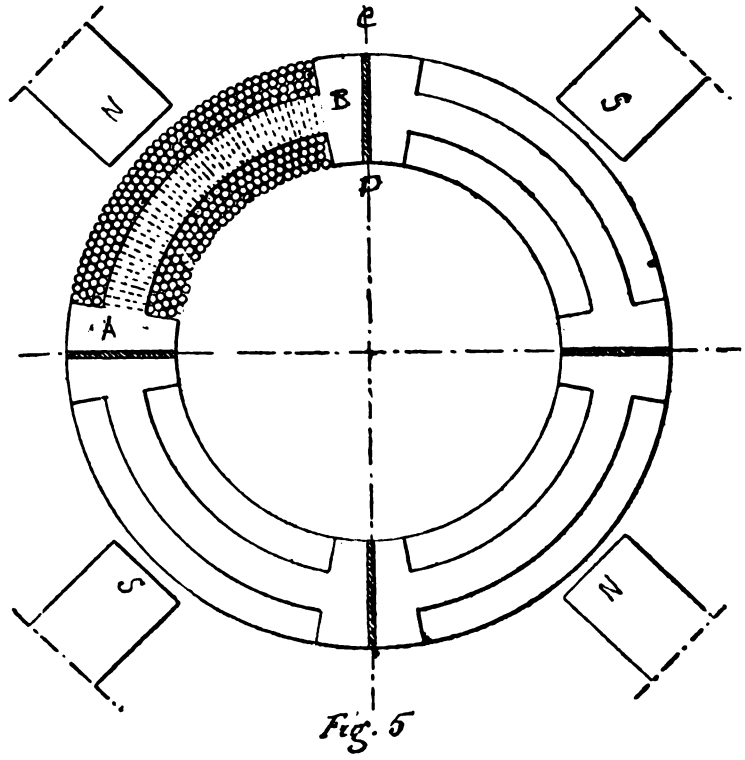

Fig. 5

Figure showing the principle of the apparatus.

Scale, 1-10th of the original.

It is true that the speed of this machine is greater, 700 revolutions per minute, but I have been assured that it gives only 68 kilogrammes of motive force, or little more than one-horse power, and it scarcely gives any heat at all.

It is of very small size, and the elements of its construction are simple, and of easy adjustment and construction.

The advantages of this kind of machine lie in the fact that, to the induction currents generated in the wheel of the Gramme, are added those which are produced in ordinary magneto-electric machines.

In order to understand this, let us imagine a Gramme wheel (Figure 5) divided, for sake of illustration, into four sections, magnetically insulated the one from the other, and forming, therefore, four electro-magnets, with arcs placed end to end; let us suppose that the iron core of each of these sections is terminated at the extremities by a piece of iron A B, forming, as it were, an extension of its poles, and that all these pieces are united in the middle by the copper C D, forming a solid wheel, round which are placed the permanent magnets N S, N S, with opposite poles opposed to one another.

Let us notice what takes place when this wheel makes a complete revolution, and also see the results produced, for instance, by the approximation of the extended Pole B, and when, moving from left to right, it approaches N. That instant it will develop in the electro-magnetic helix a current induced by magnetism, as in

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the Clarke machine. This current will be instantaneous, and the inverse of the currents in the inducing magnet (Ampère's currents). It will be very strong by reason of the proximity of B to the pole N; but the wheel as it revolves causes a series of magnetic disturbances between the pole N and the core A B, and these give rise to a series of currents which I have called "polaric reversion" currents, and which will show themselves between B and A. These currents will coincide directly with those generated at N, but they will not be instantaneous, and will go to increase the energy of B and A.

These currents are simultaneously joined by the dynamically induced currents arising from the ends of the helix passing before the pole N. When A has left N, a demagnetical current is produced equal in strength, and of the same kind as the magnetical current arising from the approach of the extended B to the pole N.

Thus currents are induced the inverse of the inducer by means of the approach and retreat of the expanded B or A; currents are directly induced during the passage of the length of core A B before the inducer; and currents are directly induced from the passage of the helices before N; so that every cause of induction is here found in combination.

It will be noticed that the action which we have just seen in a single section of the wheel takes place at the same time in all the others, and in addition to this there are also the currents which result from the lateral reaction of the poles A and B on those contiguous to them.

In order to further increase the effects of induction, M. de Méritens filled the core A B and the ends A and B with thin plates of iron cut as seen in the figure, heaped one on another to the number of 50, being each one millimeter thick; the wire of the helices being also so wound that the currents induced could be regulated in strength or number as required.

We did not notice that in the theoretical figure we have only given four sections. In reality, there may be a far greater number, and in the model we speak of there are 16, which will easily be distinguished in Fig. 1. They are mounted in a bronze wheel, fitted in a driving shaft.

Below this wheel are fixed the magnetic inducers, whose polar extremities will be seen at A A', and which are firmly fixed upon two pieces of bronze in a horizontal position (see Figs. 2 and 3). The manner in which this adjustment is effected will be seen at A".

However little one may look at the method of placing the induction wheel, it is evident that the best possible condition of construction is aimed at. In fact, as each section is isolated it can be taken to pieces separately, and, in consequence, can be surrounded with wire without any trouble. Those who know the difficulty of winding wire on the Gramme wheel can readily appreciate this advantage. Again, the placing in juxtaposition on the core of pieces of iron which can be removed with one blow of the punch is a wonderful advantage, as this method does away with the exactitude necessary in making the wheels, which are always difficult to keep perfectly round.

Lastly, there is no commutator and no collector in the machine, and consequently no loss of current.

Figures 2 and 3 represent the vertical section and the details of construction of the machine, which can be comprehended without further explanation.

We have seen that the currents given by this machine can light 3 or 4 Jablochkoff lights fitted with an electric light regulator; but it is also capable of working the ordinary lamps, even when the carbons are separated by a distance of 3½ centimetres. These results are certainly of great importance, and we augur well for the future of this machine.

All those who were present at the experiments were astonished.

This kind of machine has been ingeniously constructed by MM. Chardin and Cerjot, aided by M. Maurin.

From *L'Electricité*. TH. DU MONCEL.

(TO BE CONTINUED.)

CORRESPONDENCE.

THE SUPERANNUATION FUND.

TO THE EDITOR OF THE ELECTRICIAN.

DEAR SIR: When an interesting public subject is ventilated in the newspapers the letters for insertion are usually so numerous that the editors are obliged to suppress a great many of them, simply through want of space. I fully expected that, after *The Electrician* of the 24th and 31st August had been read by the hundreds of telegraphists whose welfare it discussed, you would likewise have found it necessary to resort to suppression in consequence of an overwhelming influx of communications. But I was deceived. Week after week since I have scanned *The Electrician* in the hope of seeing published approvals of the superannuation scheme. But, no, not a word; the Egyptian Sphinx could not be more silent. Silence cannot be accepted as an equivalent for consent in an important matter of this kind, and the more outward appreciation the idea meets with the sooner it will ripen and bear fruit. Doubtless, the subject has created a considerable amount of interest locally amongst members of the telegraphic service; but "local" interest is not sufficient—it needs be *general*. Talking it over in the mess-room, exhausting the subject, and then dropping it without further ado, does not contribute one iota towards attaining the desired object. The telegraphic world should ring with the approvals of those who hereafter hope to gather in their individual harvests. But a good harvest cannot reasonably be expected unless the seed be seasonably and abundantly sowed.

You, sir, have kindly expressed your willingness to publish letters bearing on this vital subject, and, if a number of representative communications went the round of *The Electrician's* wide circulation, *general* interest would soon be ensured. Furthermore, such manifestations of approval, emanating from different stations, would undoubtedly please the boards of directors and stimulate them in their efforts to organise a plan which, when established, will, like a sun-ray, brighten the dark and cloudy horizon of the telegraphist's future. Now, while we are young—many brimming with youthful hopes and fancies—we cannot realise, in our inexperienced minds, the benefits of a pension; the worth of such boons seldom is appreciated until the eleventh hour, when we find the door closed against us, and there is nothing left for us but to continue on our way murmuring, regretfully, "Too late!"—Yours, &c. SUPPORTER.

Nov. 25th.

MR. HERRING'S GRIEVANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Herring's lengthy communication in your issue of the 30th ult., has two aspects, one relating to his negotiations with the authorities of the Postal Telegraphs, the other as touching his right to petition the Crown. I fail to see what concern the readers of *The Electrician* have with either of these. We should, perhaps, be interested to know whether his invention was or is a good one; whether it has been exhibited, and with what verdict; whether adopted by foreign or cable administrations; whether, in short, the public service has suffered by official blindness to the merits of his proposal. If he cannot satisfy us on these points, why does he appeal to us? It is edifying to learn that all British subjects have a right to petition the Crown; but, unless the charter of liberty also provides that every such petition shall be acceded to, the information is of small value to us. Mr. Herring deserves and has our sympathies as an inventor, who has spent a lot of money on what has not proved acceptable to the public department for which he intended it. He may, for all we know, have a substantial grievance in the background; but, so far as his letter goes, it makes clear only this exceptional feature in his case—differing from that of most other unsuccessful applicants—namely, that he persistently *courted* a blunt condemnation, while the authorities steadily maintained a cold civility. Speaking for myself, I am willing to accept Sir W. Thomson's and Professor F. Jenkin's dictum rather than Mr. Herring's disparagement of it; moreover, I don't see any great crime in the Government reconsidering their permission to grant a fresh trial. Perhaps they had good reason for it. I don't know whether they had or not; and, I am bound to say, I don't care; for, as a subscriber to this journal, I think he ought not to obtrude his troubles upon its readers, but bear them like many another disappointed man.—Yours, &c., J. L.

Nov. 30, 1878.

[We can hardly agree with our correspondent. An Englishman's privilege is not a thing to be lightly considered, and it concerns the man of science as much as the man of politics.—ED. *E.*]

THE MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. C. V. de Sauty could, of course, use a Reiss receiver for the microphone if he is content with what that method will do for him. But it is incapable of articulation, and is not particularly sensitive. See an article on "Microphone Receivers," which appeared in No. 24 of *The Electrician*.—Yours, &c.,

ANCHOR.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

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THE LIGHT FROM INCANDESCENT PLATINUM.

It is important that we should return again and again to the subject of electric lighting, inasmuch as new material is daily placed before us, and the constant attention devoted to it from many and diverse quarters must necessarily result in fresh discoveries. We have before this warned our readers against too rapidly coming to a conclusion. The "electric light" is undoubtedly destined to create more or less of a revolution in our systems of lighting, but the method which will ultimately be adopted has not yet been published. It may be that it is in embryo, that even now the records of the Patent Office might give the clue; but, as a matter of fact, the systems at present before the public must be considered as skirmishers, destined to be withdrawn before the main forces are brought into action. Scientific workers know fairly well what is required, and, broadly speaking, there are only two directions in which progress can be made. We were a little surprised the other day to read that electricians ought no longer to consider Ohm's law as anything but empirical, practically giving accurate results in a number of ordinary cases, but, when tested with dynamo-electric machines of the Wallace-Farmer type, for example, giving fallacious results. We shall with some anxiety await the figures of Messrs. Fox and Ladd in proof of this statement, but meanwhile we shall maintain the accuracy of the law. Then, again, other workers either do not know that Joule has given us the law for the heating effects of the current, or wilfully mislead the public in putting forward what they know to be useless as inventions of great importance. Tyndall has spoken in no doubtful manner on his experimental results, which ought to assist workers in avoiding certain pitfalls. The laws relating to dynamo-electric machines are fairly well known, and it is not difficult to point out where improvements might be made in existing machines. We shall hardly be held to have made a breach of confidence in giving an example of this. The Weston machine, recently described in these columns, was, on its first introduction, criticised by one of our most active and conscientious writers, Mr. Sprague, who suggested certain improvements. If anyone cares to hunt through the files of the Patent Office, they will find that, since the criticism appeared, improvements have been made in the Weston machine, and in the direction indicated. The same gentleman has, we see, recently taken out patents himself for improved machines for the generation of electricity, and we have no doubt that when his designs are fully known it will be found he has made considerable improvements. We have some faith in this case, but now let us take another. Mr. Edison, who has a great talent for invention, turned his attention to the electric light, and sent telegrams hinting that he had solved a problem which was in reality no problem, and had succeeded in doing that which had hitherto been found to be impossible. Gradually, what Mr. Edison had done leaked out, and then electricians were not slow to speak of failure; but we are not sure that such outspokenness is not premature, and that the criticism so freely and forcibly uttered will not have an effect opposite to that intended. If Mr. Edison possesses any of the power commonly attributed to him, he will sit down and calmly consider what his critics say, stop all work in the direction he originally tried, and really "make a new departure." As our readers are aware, we were the first in Europe to give the clue to the direction in which Mr. Edison was working and from the first we pointed out that what the New York papers reported him as having accomplished was an impossibility. We shall endeavour to completely destroy the idea of incandescent platinum as an economical illuminating medium by quoting Professor Tyndall's remarks on the subject, and till these are proved to be incorrect incandescent platinum will fail to force its way. On pp. 428-9 of "Heat as a Mode of Motion," 4th Ed., we read: "A rock salt cell filled with the *transparent* bisulphide of carbon was placed in the front of the camera, which contained the white hot platinum spiral. The transparent liquid was then drawn off, and its place supplied by the solution of iodine. The deflections observed in the respective cases are as follow:—

"RADIATION FROM WHITE HOT PLATINUM:

Through transparent liquid.	Through opaque liquid.
73·9°	73·8°
73	72·9

"*All* the luminous rays passed through the transparent bisulphide, *none* of them passed through the solution of iodine. Still we see what a small effect is produced by their withdrawal. The actual proportion of luminous to obscure

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rays, as calculated from the above observations, may be thus expressed:—*Dividing the radiation from a platinum wire raised to a dazzling whiteness by an electric current into* 24 *equal parts,* 1 *of these parts is luminous and* 23 *are obscure.* A bright gas flame was substituted for the platinum spiral, the top and bottom of the flame being shut off, and its most brilliant portion chosen as the source of rays. The result of forty experiments with this source may be thus expressed:—*Dividing the radiation from the most brilliant portion of a flame of coal gas with* 25 *equal parts, one of those parts is luminous and* 24 *are obscure.* I next examined the ratio of obscure to luminous rays in the electric light. . . . .

"It is not easy to obtain perfect steadiness on the part of the electric light, but three experiments carefully executed gave the following deflections:—

"RADIATION FROM ELECTRIC LIGHT:

	Through transparent C S·2.	Through opaque solution.
Experiment No. I.	72·0°	70·0°
Experiment No. II.	76·5	75·0
Experiment No. III.....	77·5	76·5

Calculating from these measurements the proportion of luminous to obscure heat, the result may be thus expressed:

"*Dividing the radiation from the electric light produced by a Grove's battery of fifty cells into ten equal parts, one of those parts is luminous and nine are obscure.*"

Prof. Tyndall was not experimenting with any direct reference to the electric light as a medium for ordinary lighting purposes, and therefore his results are all the more to be regarded. These results prove that the electric light, *i. e.*, the light emitted by the voltaic arc, gives a ratio of light to heat more than double that of the white hot spiral of platinum; in fact, other experiments showed that the ratio is almost that of 2·5 to 1. Even had not this remarkable result been obtained by direct experiment, it should be seen to be the case by a cursory glance at Joule's law, which may be thus stated: "The amount of heat generated in a given time varies directly as the product of the resistance of the wire into the square of the strength of the current" ("Ency. Brit." 9th Ed., Part 29, p. 56). The writer of the article just quoted goes on to show (p. 57) that the formula $H = R I 2 t$ can be directly deduced from Ohm's law. Thus, in the progress of events, if Messrs. Fox and Ladd manage to overthrow Ohm's law, we may see also that of Joule overthrown, and have to acknowledge that hitherto we have marched in ignorance, and that the experimental results from various quarters which so strongly corroborate the truth of these laws have been evolved from the inner consciousness of the experimenters.

ON SOME IMPROVED METHODS OF PRODUCING AND REGULATING THE ELECTRIC LIGHT.*

Among the manifold functions which the elementary substance carbon performs in organic nature, not the least important is that by which it becomes the great source of artificial illumination, whether derived from oils, coal gas, or from coke rendered incandescent by the action of powerful electric currents. Since the time when Davy first produced the voltaic arc, between two points of wood charcoal, through which was transmitted the current from the great battery of 2,000 plates belonging to the Royal Institution, many experiments have been made to determine the best kinds of carbon for developing the electric light. The carbon which, until recently, was most commonly employed for this purpose is obtained from the sides of gas retorts, where it accumulates in the form of coke during the destructive distillation of coal. The shells of coke from the retort are sawn up into pencils from one quarter to half an inch square, and from six to nine inches in length. Although very good results are obtained from carbon of this kind, it is a difficult material to work on account of its hardness, and it sometimes contains impurities which interfere with its conductivity. It is also liable to fracture when suddenly heated by the transmission of powerful electric currents. These defects have led to the introduction in electric lighting of artificial carbon, composed of powdered coke and lampblack, formed into a paste with molasses and gum. This material is pressed into cylindrical forms, and subjected for a given time to a high temperature in a special furnace. The manufacture of these carbon pencils has attained great perfection in the hands of Carré, of Paris, and they can be made into perfectly straight and cylindrical forms of from two to sixteen millimetres in diameter, and half a metre in length.

When the electric light is to be used for illumination, it is necessary that it should be as continuous as other modes of lighting. For this purpose not only should the current be regular in its action, but the distance between the carbon points must not alter, which necessitates the use of some arrangement for bringing them nearer together in proportion as they are consumed. Much ingenuity has been displayed by electricians in solving this problem, and the automatic contrivances invented by Staite, Duboscq, Foucault, Serrin, and others, leave little to be desired in regard to the steadiness of the light, when the regulators are in good order and in the hands of intelligent operators. All automatic instruments, however, from the delicacy of their mechanism, are liable to derangement, and their action is not easily understood by persons not having a special knowledge of their construction. To obviate the objection to the use of such instruments by unskilled attendants I devised, a few years since, a regulator for use on H.M 's ships of war, to be actuated by hand. In this arrangement the carbons are made to approach and separate from each other by means of a right and left-handed screw connected with the carbon holders. Each of the screws, with its carbon holder, can be actuated independently of the other, for the purpose of adjusting the points of the carbons to the proper focus of the optical apparatus used in connection with it. The regulator, with its carbon points, is placed in the focus of a dioptric lens, which parallelises the divergent rays of light into a single beam of great intensity. The lens with the regulator is pivoted horizontally and vertically on the top of a short iron column, fixed on a raised platform above the deck, and the beam of light may be projected upon any distant object within its range. This special application of the electric light, however, as will be seen, requires the frequent adjustment of the carbons by the operator; but, as he is always required to be in attendance to manipulate the projector, no inconvenience is experienced through the absence of the automatic arrangement. This method of regulating the electric light has now been in use in the Royal Navy for more than three years, and has proved very satisfactory.

Simultaneously with the progress of improvements in the mechanism for regulating the electric light, experiments have been made with the object of dispensing with the regulator altogether. The most recent, as well as the most successful, of these attempts has been made by M. Jablochkoff, a Russian inventor. In the specification of his letters patent of 1877 he proposes to place the carbons side by side (as had been previously proposed by Werdermann in 1874), and to separate them by an insulating substance to be consumed along with the carbon. The inventor states that the insulating substance for separating the carbons may be kaolin, glass of various kinds, alkaline earths, and silicates, which he prefers to apply in the form of powder rammed into an asbestos cartridge case containing the carbons. A powder which the inventor found serviceable consists of one part lime, four parts sand, and two parts talc. These materials are rammed into the cartridge case surrounding and separating two parallel sticks of carbon placed in the case, at a little distance apart. One of the carbons is made thicker than the other to allow for its more rapid waste. The lower ends of the carbons are inserted into pieces of copper tube or other good conductor, separated from one another by asbestos, and the ends of the tubes are pinched between two limbs of a screw vice, connected respectively to the conducting wires. This combination of carbons and insulating materials the inventor terms an electric candle, which, when mounted on a stand or candlestick, has the appearance of the Roman candle of pyrotechnists. The inventor further states that the heat produced by the electricity fuses the material between the carbons and dissipates it; and the freedom of the passage afforded by the fused material to the electric current permits the subdivision of the light by placing several lamps in the course of one electric circuit. It is also stated that the construction of the candle may be varied; and, among the forms described, is one in which the carbons, instead of being contained in a cartridge case, are separated by a partition of kaolin or other similar insulating material.

I have thought it well to describe, as nearly as possible in the

* Paper read by Mr. Henry Wilde at the Manchester Literary and Philosophical Society, October 29.

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words of the inventor, the electric candle, which is now the subject of so much attention in its application to electric lighting, so that its relation to what follows may be more clearly perceived. A remarkable peculiarity of the direct current in electric lighting is that of its consuming the positive carbon at twice the rate of the negative one, and while the negative carbon is a pointed cone, like that of a pencil, the positive pole takes the form of a hollow cavity or crater.

M. Jablochkoff's early experiments seem to have been made with the direct current, and hence his carbons are described as being of unequal thickness, in order that the positive and negative carbons of the candle might be evenly consumed. When the alternating current is used for producing electric light, both carbons are of the same thickness, and are consumed at an equal rate, and both points terminate in regular cones. This property of the alternating current, besides other advantages, always maintains the luminous point in the focus of any optical apparatus used in connection with it, that is, when the carbons are placed end to end, as I had occasion to point out in a former paper read before the Society in 1873, on an electro-magnetic induction machine for producing alternating currents.

M. Jablochkoff, in the course of his experiments, would appear to have met with some difficulties in adapting the direct or continuous current to a system of lighting with his electric candles, and now uses the alternating current for this purpose. The candle has also been simplified by substituting a slip of plaster of Paris for the cartridge and partition of kaolin formerly employed.

To produce the alternating currents, however, to supply a number of lights, it was found necessary to employ powerful electro-magnetic induction machines, excited by the currents from other smaller machines, according to the principles laid down in my paper read before the Royal Society, and published in the *Philosophical Transactions* of 1867. From sixteen to twenty lights are produced from one of these electro-magnetic machines, each light absorbing about one-horse power.

The system of electric lighting above described would now seem to be definitely established in some places as a substitute for gas, and visitors to the French capital during the present summer will have been struck with the fine effects produced in the avenues and squares where the light is displayed.

My connection with the history of this system of lighting placed me in a position to make some experiments with the Jablochkoff candle, and led to the discovery of the following facts. One of the conditions necessary for producing a constant light from the candle, in its most recent form, was that the quantity and intensity of the alternating current should be such that the carbons consume at a rate of from four to five inches per hour. If the electric current were too powerful, the carbons became unduly heated, and presented additional resistance to the passage of the current; the points at the same time lost their regular conical form. If, on the other hand, the current were too weak, the electric arc played about the points of the carbons in an irregular manner, and the light was easily extinguished by currents of air.

In the course of these experiments I was struck with the apparently insignificant part which the insulating material played in the maintenance of the light between the carbon points; and it occurred to me to try the effect of covering each of the carbons with a thin coating of hydrate of lime, and mounting them parallel to each other in separate holders, and without any insulating material between them. The use of the lime covering was intended to prevent the light from travelling down the contiguous sides of the carbons. On completing the electric circuit the light was maintained between the two points, and the carbons were consumed in the same regular manner as when the insulating material had been placed between them.

Two plain cylindrical rods of carbon, three-sixteenths of an inch in diameter, and eight inches long, were now fixed in the holders parallel to each other, and one-eighth of an inch apart. The strength of the alternating current was such that it would fuse an iron wire 0·025 of an inch in diameter, and eight feet in length. On establishing the electric current through the points of the carbons by means of a conducting paste composed of carbon and gum, the light was produced, and the carbons burnt steadily downwards as before.

Four pairs of naked carbons mounted in this manner were next placed in series in the circuit of a four-light machine, and the light was produced from these carbons simultaneously, as when the insulating material was used between them. The light from the naked carbons was also more regular than that from the insulated ones, as the plaster of Paris insulation did not always consume at the same rate as the carbons, and thereby obstructed the passage of the current. This was evident from the rosy tinge of the light produced by the volatilisation of the calcium simultaneously with the diminution of the brilliancy of the light from the carbons.

The only function, therefore, which the insulating material performs in the electric candle, as shown by these experiments, is that it conceals the singular and beautiful property of the alternating current to which I have directed attention.

As I have already said, the strength of the alternating current must bear a proper proportion to the diameter of the carbons used, and when a number of such lights are required to be produced in the same circuit, the quantity and property of the current will remain constant, while the tension will require to be increased with the number of lights.

This simple method of burning the carbons will, I believe, greatly further the development of the electric light, as the carbons can be used of much smaller diameter than has hitherto been possible. They may also be of any desired length, for as they are consumed they may be pushed up through the holders without interrupting the light. One of these developments will be a better method of lighting coal and other mines. In this application the alternating currents or waves from a powerful electro-magnetic induction machine may be used for generating, simultaneously, alternating secondary currents or waves in a number of small induction coils, placed in various parts of the mine. The light may be produced in the secondary circuits from pairs of small carbons enclosed in a glass vessel having a small aperture to permit the expansion of the heated air within. Diaphragms of wire gauze may be placed over the aperture to prevent the access of explosivive gas. By generating secondary currents or waves without interrupting the continuity of the primary circuit, the contact breaker is dispensed with, and the subdivision of the light may be carried to a very great extent.

ON THE PRACTICAL APPLICATION OF ELECTRICITY TO LIGHTING PURPOSES.*

By JAMES N. SHOOLBRED, B.A., Mem. Inst. C.E.

On Wednesday afternoon the premises of this Society, in Adam-street, Adelphi, presented a scene of great activity. In the hall of the institution, an eight horse-power Crossley gas-engine, which arrived only on the preceding Monday, was already at work, being the prime motor for two Gramme machines of the M type, and for the machine of the A type. At the back of the premises a small steam engine was located, together with a Siemens' dynamo-electric machine. In the theatre upstairs, the various lamps were being adjusted and tried; a large Siemens-Halske lamp being suspended from the ceiling, whilst several lamps of M. Rapieff were to be seen upon the table, and others of the construction adopted by M. F. Suisse were distributed in the vicinity of the entrance. The Suisse lamp is a modified Serrin of great simplicity, about twenty pieces used in the construction of the original instrument having been suppressed. It is claimed for this lamp, which has been in use for some time past at the Chemin de Fer du Nord in Paris, that it will burn for as many as sixteen hours consecutively; whilst that of Serrin would burn only for a period of from three to four hours.

A considerable number of diagrams and illustrations of machines for the production of the electric current, including illustrations of the Méritens machine—were affixed to the walls of the theatre. The paper read was as follows:—

The object of the present communication is to present some of the results of a few of the actual applications of the electric light to illumination for industrial purposes, which have been in operation for a period of time and under such conditions as to cause each to have passed beyond the stage of a mere laboratory experiment. Any cases or processes which have not passed beyond this preliminary stage, or which have not yet received actual industrial application, have, as far as possible, been avoided.

The remarks which follow must be taken as the continuation of a communication "on the Present State of Electric Lighting, made last August to the British Association for the Advancement of Science, the purport of which was the description of some of the scientific tools, such as electric machines, lamps, carbons, &c., which are made use of in practical illumination by electricity; while the present communication will endeavour to give the commercial results of the working of those instruments.

A general knowledge of the principles and form of construction of the best known of these electrical machines and lamps will, therefore, be assumed, in order to avoid again travelling over the same ground. The diagrams of some of them are, however, placed upon the walls, and, if time permit at the conclusion of the paper, a brief description may be given of them.

PERIODS IN ELECTRIC ILLUMINATION.

Electric lighting, it will be found, divides itself very readily

* A Paper read at the Society of Arts, 4th December, 1878.

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into certain marked periods, each representing a clearly defined progress from that attained in the preceding one. It has been found convenient to divide them into three, which division will, in the following remarks, be still adhered to. These stages may be briefly described as—

1st. That of lighthouse illumination by the Holmes and by the Alliance magneto-electric machines, giving off currents alternating in direction, and producing a single very powerful light.

2nd. That of dynamo-electric machines producing a single light each for industrial purposes generally; in addition to lighthouse illumination. The Siemens* and the earlier Gramme are the best known in Europe of these machines; while the Wallace-Farmer and the Brush claim most attention in the United States.

3rd. That of machines, both of magneto and of dynamo construction, and generally (though not necessarily) giving off alternate-direction currents, which afford facilities, if provided with suitable lamps, for the production of a number of lights from each machine. Besides the already named Holmes and Alliance machines, and their recent and more compact successor, the de Méritens, all being of magneto construction, there are the Lontin (double) and the Gramme (double), which also effect this much desired object. The two last named machines, though dynamo in construction and in principle, are by some persons classed as magneto machines in their operation, inasmuch as the initial or generating machine of each maker acts like a permanent magnet to its second or dividing machine, and affords to it a supply of electricity. Still, it may be replied, while the "generator" in each case most certainly acts on the dynamo principle, the "divider" does so also, as it greatly augments the electric current received from the former before it delivers it as its final output.

It may not be out of place here to mention that the word "magneto" implies (to the author at least) a machine where permanent steel magnets are used to induce the electric current into an electro-magnet—*i.e.*, where a coil of copper wire is wound round a cast-iron core; while the term "dynamo" indicates that electro-magnets only have been used in the construction of both the inductor and the induction parts of the machine.

PRACTICAL APPLICATIONS.

1st Stage.—The Corporation of the Trinity House have made use regularly of the electric light as an illuminant ever since 1871, in two of their lighthouses—at Souter Point, on the coast of Durham, and at the South Foreland, near to Dover. The apparatus used in both cases is nearly the same. That at the last-named lighthouse formed part of the different electric apparatus made use of by Mr. James N. Douglas, the engineer to the Trinity Board, in his experiments at the South Foreland to ascertain the relative merits of certain electric machines as available for lighthouse illumination, and it is described in his report upon those experiments.

It consists of two of Holmes's magneto-electric machines, used either singly or coupled up together, and driven by steam engines of 10 h.-p. nominal. The current given off in each case is alternating in direction, and serves to feed a Serrin lamp with square carbons, ⅜ inch a side, made by Carré, of Paris, the rate of consumption of the carbons being about four inches per hour, the actual motor power per light ranging from 3 to 4 h-p. per hour as indicated; while the intensity of the naked light produced has an hourly ordinary intensity (measured horizontally) of 1,523 standard sperm candles with a single machine, augmenting to a maximum of 3,046 candles when the two machines are coupled together. The annual cost of such lights, including engine power, carbons, wages of men, repairs, and interest at seven per cent. on first cost is about £1,035; this, at a total of 4,012 working hours during the year, gives an hourly expense of 5s.

2nd Stage—Lizard Lighthouse.—The Corporation of the Trinity House, in consequence of the recommendation of Mr. Douglas, supported by Dr. Tyndall, the result of the experiments at the South Foreland just referred to, have established, now nearly twelve months ago, at this their latest application of the electric light, a series of six Siemens dynamo-electric machines, each of the type known as "4,000 candles;" and which are driven by three caloric engines. Of the three electric engines thus formed, a single one may be driven under ordinary circumstances to produce one light of an hourly intensity of 4,100 standard candles; or else the two may be coupled together, as is the case in thick weather, and an intensity of 8,500 candles afforded by the light; the average amount of motor power per hour for a single machine being about three horses. The annual working expenses, under similar conditions to the preceding case, came to about £494, or about 2d. per hour. The results at the Lizard point, therefore, to a more abundant light produced at a cheaper rate absolutely than with the older machines at Souter Point and at the South Foreland.

While considering these applications of the electric light to lighthouse illumination, it is but right to remark that they take place under circumstances and conditions special to themselves, and which do not exist in the case of industrial or other works. These arise in part from the paramount necessity of providing in the lighthouse an illumination of the most perfect character, and abundant in intensity, as well as of providing an amount of extra plant to guard against any cessation in the illumination. The generally isolated situation of the lighthouse also adds to the cost of the materials employed, and causes the personal staff employed to be of a more skilled class, than where assistance in the matter of repairs is readily available. Any comparison, on purely economical grounds, between the electric illumination in lighthouses and in industrial works, must necessarily be unfavourable to the former.

(TO BE CONTINUED.)

* This machine will be described and illustrated in our next issue.

THE TROUVE ELECTRICAL POLYSCOPE AND SAFETY LAMP, FOR POWDER MAGAZINES, MINES, DIVERS, CORAL AND OYSTER SEEKERS, &c.

The electrical polyscope, or the modification of it which constitutes the safety lamp, is composed of:—

1st. A reservoir in which dynamical electricity may be stored up, *i.e.*, a secondary battery of M. Planté.

2ndly. A series of reflectors, with or without mirrors, adapted for various modes of illumination, whether it be that requisite for a powder magazine, or that adapted for cavities in the animal organism. These reflectors are all parabolic. The reflecting lamp intended for powder magazines is provided with a double transparent envelope, which affords the requisite protection.

3rdly. A battery of four Trouvé-Callaud elements, for the purpose of charging the reservoir, together with various conductors and a stand, to which may be attached the reflectors of the safety lamp.

4thly. Of a special resistance coil or regulator of extreme simplicity, intended to regulate the flow of electricity from the reservoir. We use here the term "flow" of electricity, because those who are acquainted with secondary batteries will understand how analogous these are to a hydrostatic reservoir. The adjustment obtained by means of this regulator is so perfect that platinum wires, varying in diameter from 1-15th millimetre to 1½ millimetre, may be raised to a temperature approaching the point of fusion of the metal without any danger of actually reaching this point.

5thly. A double-circuit galvanometer in which the electromotive force of the reservoir and that of the battery are in opposition. Thanks to this simple and ingenious arrangement, the operator or the practitioner can always know, on the one hand, the capability of the battery to effect the charge of the reservoir, and, on the other hand, the degree to which the reservoir is actually charged. Thus, when the reservoir is completely exhausted, the needle returns to its initial position, *i.e.*, to a *minimum* deflection of 30°. Should the deflection be less than this, it may be concluded that either sulphate of copper or a zinc element requires to be supplied.

The utility of the apparatus in the case of powder magazines will readily be understood. At the entrance to each magazine is placed a box containing three or four Trouvé-Callaud elements; and on the box is stood the reservoir or secondary battery, the charge of which is to be maintained by the primary elements in question. Whenever the artillerist requires to enter the magazine, he takes the reservoir in one hand, and in the other the stand which carries the reflector; and, the moment he completes the circuit by means of the key attached to the stand, the darkness is dispelled by the magic light of this ingenious apparatus, a light which, if necessary, will last for several consecutive hours. In case of accident, the artillerist would carry with him a duplicate reflector, which could be substituted for the other upon the stand. On leaving the magazine, he would replace the secondary battery

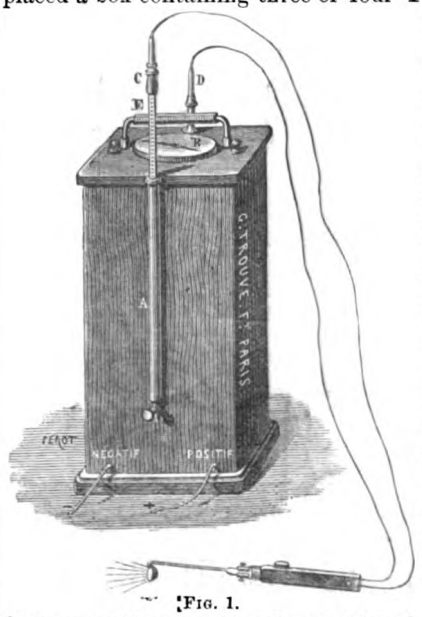

FIG. 1.

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upon the box containing the primary, in order that the former may accumulate afresh the quantity of electricity which has been expended.

We will now describe the various modifications of the apparatus, adopting the chronological order in which they have been invented or contrived.

Mode of Using the Apparatus.

The apparatus being charged, the rod belonging to the graduator is drawn out to the full extent; the two conductors are adapted to the reservoir, and the handle attached to their extremities.

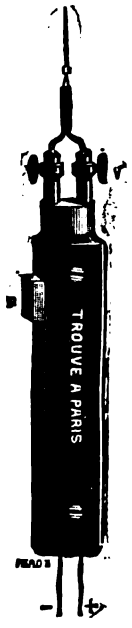

Fig. 2.

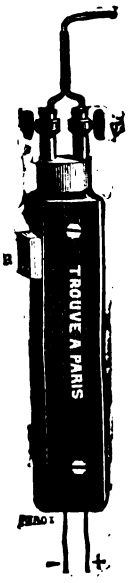

Fig. 3.

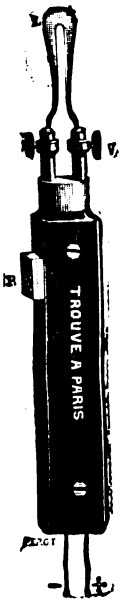

Fig. 4.

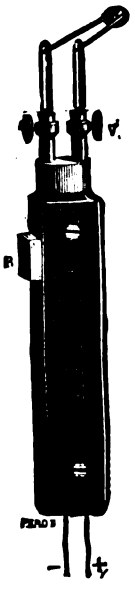
Fig. 5.

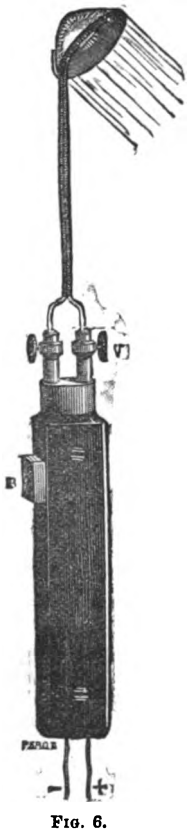
Fig. 6.

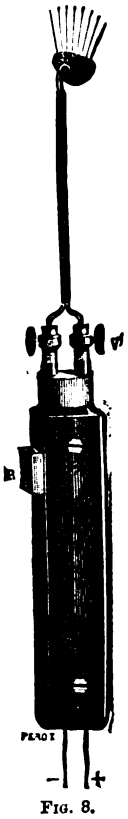
Fig. 8.

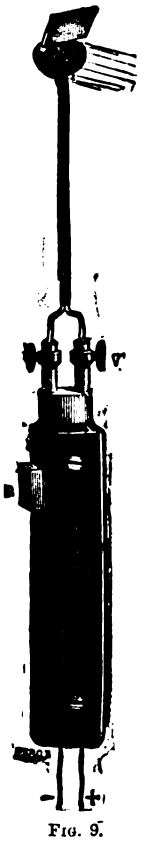
Fig. 9.

The handle then receives the reflector, or cautery, that may be required. The current is turned on by pressing the key; and the incandescence of the cauteries, or the illumination of the reflectors, is obtained by lowering the rod until the requisite heat or light is obtained.

Since the electromotive force in this apparatus is constant, the requisite position of the graduator may be observed once for all, and may be reproduced in succeeding operations without any fear of fusing the platinum wire. If by any accident the fusion should occur, another platinum wire, ready prepared, will be found inside the case. The platinum is replaced in exactly the same way, whatever may be the kind of reflector used, by means of a pair of small pliers, with which the platinum may be properly fixed in the slits practised in the conductors of the reflector holders. A small pad is supplied for the purpose of renewing from time to time the polish of the reflectors. It may here be observed that the screws attached to the handles are not indispensably necessary, since the rods fit tightly into the handles. Such details are of practical importance, since, in transporting the apparatus, the screws are apt to be lost.

Explanation of the Cuts.

Fig. 1. This represents the polyscope in action. A is the regulator for the current from the reservoir contained within the box. B is the double-circuit galvanometer. C and D are connecting pieces for the wires between the handle and the poles of the reservoir. The rod E of the regulator constitutes one of these poles. The handle, with its key for turning on the current at will, is shown attached to the wires, and the reflector with the coil of platinum wire to be heated to incandescence is affixed to its extremity.

Fig. 2. This represents a very attenuated cautery adapted for the removal of hair, operations upon projecting tumours of small volume, &c.

Fig. 3 is a "bird's beak" cautery for dentists, also serviceable for opening abscesses, &c.

Fig. 4 is a cautery in the form of a knife, for small operations.

Fig. 5 is a cautery for the application of heated points.

Fig. 6 is a mouth illuminator for dentists. So great is the power of this reflector that the teeth become quite transparent, and their condition can be observed in every detail. Placed at the extremity of an "œsophagian probe," it serves to light up the stomach, which it renders transparent.

Fig. 8 is a reflector adapted for the illumination of cavities in the generality of cases occurring in medical practice. It will be observed that the light may be brought as closely as may be requisite to the surface which is to be illuminated, whilst the eyes of the operator are completely shaded from it.

Fig. 9. This represents a reflector with hinged mirror, as constructed for Dr. Ålrin, for special rhinoscopic purposes. Other apparatus for special medical use, such as the urethroscope, the opthalmoscope, and the otoscope, can be supplied on demand.

THE METEOROLOGICAL SOCIETY.

On Thursday, Nov. 28, a meeting of this Society was held at the Institute of Civil Engineers, Great George-street, Westminster, when a most interesting lecture was delivered by Mr. George James Symons, F.R.S., on "Rain, Snow, Hail, and Atmospheric Electricity." The chair was occupied by Mr. Siemens.

The Chairman having introduced the lecturer,

Mr. Symons said he was asked to tell them all about rain in the course of one hour and a quarter, or less, but to "boil down" twenty years' experience in that brief space was not the easiest task imaginable. For this reason he had tried partly to anticipate his remarks by putting some papers on the seats containing the rules to observe, and similar information. Turning to his lecture, he explained that rain was condensed vapour. The atmosphere consisted of oxygen, nitrogen, dust, and sundries, all which were classed as dry air, and also of a variable quantity of water in the state of vapour. As to where rain came from, the question might be answered as regarded this country in three words, "the West Indies." The chief cause of rain was condensation by cold, and the largest amount was found in hilly districts, exposed to currents of air coming direct from warmer oceans. He then went rather fully into the subject of measurement of rain. Probably there were a hundred different patterns of gauges, but he would deal with two—the pattern of gauge used in very wet and mountainous districts, which he described as merely a double cylinder, the outer one for protection, the inner one to hold the rain; and the five-inch Snowdon gauge, the pattern of which the largest number were now at work. Circular gauges were certainly better than square ones. Over a century ago it was known that the nearer one went to the clouds the less the quantity of rain collected. The precise cause of this was long and vigorously disputed, and to this moment the complete explanation of the fact had not been given; but he believed it was now acknowledged to be almost entirely due to wind. He then urged the importance of inspecting rain-gauge stations. The total number of rain-gauges regularly observed in this country was about 2,200, say 1,700 volunteer

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stations, and 500 under the following bodies:—The Meteorological Council, the Meteorological Society, the Scottish Meteorological Society, the Board of Northern Lighthouses, Mr. Glaisher, and the Manchester, Sheffield, and Lincolnshire Railway Company, every one of whom most kindly sent him copies of its records. All the water in our rivers, lakes, and wells was stored rain, and so, therefore, was every drop of water that we use. With the exception of one Irish engineer, he never heard any one maintain that drainage could be perfectly carried out without any knowledge of the fall of rain. He next spoke of the importance of a system for anticipating floods, observing that at Lyons and Paris there was a system of flood warnings in full operation, and no flood ever reached either city till long after its advent had been announced, and usually the height predicted was realised within a few inches. As to waterworks, excepting London, it might probably be said with truth that half the urban population of the United Kingdom were supplied by gravitation waterworks, *i.e.*, by the collection and storage of the rainfall on upland districts. Dealing with the last branch of his subject, atmospheric electricity, the lecturer said that both from want of time and ability he was unable to treat it properly. Had other circumstances permitted an evening would have been devoted to it. But rain, hail, and thunderstorms went together, and, therefore, *nolens volens*, it appeared in his syllabus. It used to be the fashion to ascribe to the action of electricity all unexplained phenomena, but a wiser course was now adopted, and people were not too conceited to own that they do not know everything. He would not attempt to give a connected statement respecting atmospheric electricity, but merely some scraps of information, which might, perhaps, induce others to devote themselves to the subject. Years ago, when Francis Ronalds was director of Kew Observatory, the upper portion of that building was fitted up with such a collection of electrometers as had never been established before, and had never been equalled since. Respecting the results obtained, he referred them to the reports of the Kew Committee, to Kaemtz, and to Drew. At the Royal Observatory attempts had been made for many years to observe atmospheric electricity, but they had been very unsuccessful, the insulation of the exploring wire having rarely been perfect for long together. The most elaborate experiments with exploring wires were made on the Quantock Hills in Somersetshire by Andrew Crosse. Much intensely interesting information was given in the memorials published by his widow—one statement being that frequently storm clouds appeared to be zonal, that was, alternate portions positively and negatively electrified. For ordinary and very rough purposes an ordinary gold leaf electrometer gave useful indications; but it was far inferior to even the cheapest form of Sir William Thomson's electrometer, "which is certainly the instrument of the present, and possibly of the future also." People often spoke of summer sheet lightning as harmless, and so it was to them; but he early learned that it was by no means so harmless at it looked. Many years ago, one lovely summer evening, he saw from London beautiful lightning playing along the S.W. and W. horizon. He watched it for an hour, and enjoyed the sight. Two days afterwards tidings arrived of a fearful thunder and hailstorm, at a village some thirty miles from London, and that in a row of cottages belonging to him not one pane of glass on the south side was left whole. Lightning was visible at great distances—he believed as much as 150 miles. Thunder was stated to be only audible for about ten miles; but Mr. Corder, in the October number of the *Natural History Journal*, said, under date September 8:—"Counting the seconds between the flash and thunder, I got twice up to 130 seconds, or 27 miles distant. This is the farthest I ever counted. Flammarion gives ten miles as the *maximum* distance at which thunder is audible; but I have heard it several times at about 100 seconds or 21 miles." The frequency of English thunderstorms increased with the temperature, but it was also greater with hot, damp weather than hot, dry weather. Summer thunderstorms were supposed to be more destructive than those of other periods, but the larger percentage of accidents might be due to more people being in the fields, and stupidly sheltering themselves under trees in summer. He could not understand why English people had hitherto been so slow to erect lightning conductors, nor why, when they did put them up, they were always so stunted that they looked as if ashamed to show themselves. A properly-fitted and cared-for conductor gave absolute protection to the building on which it was erected, and it was strange why some people allowed their nervous systems to be deranged, instead of so protecting their houses that they might be able to watch with calm and with pleasure one of Nature's grandest sights. Although the general principles which govern the erection of lightning conductors were well known, there were some minor points which required discussion. He was glad to end these remarks by informing them that a body of delegates from the Physical Society, the Society of Telegraph Engineers, and the Royal Institution of British Architects, had accepted an invitation from the Council of the Meteorological Society, and would shortly assemble to settle all doubtful points.

The lecturer resumed his seat amid warm applause.

On the motion of the chairman, a hearty vote of thanks was passed to

Mr. SYMONS, who, in returning thanks, cordially invited those present to attend the ordinary meetings of the Society.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).

The Extraordinary General Meeting of the Members of this Company, adjourned from the 6th ult., was held on Wednesday, the 4th inst., at the City Terminus Hotel, Cannon-street, "for the purpose of approving an Agreement made with the Governments of the Australian Colonies or some of them, for the duplication of the Australian Cable, and passing Resolutions authorising the Directors to execute all contracts and to do all acts requisite for carrying such Agreement into effect, with such modifications, if any, as the Directors may determine; and further authorising the Directors to raise the capital required for this purpose and for the general purposes of the Company, by the issue of Debentures or otherwise upon such terms and in such manner as the directors may determine."

The CHAIRMAN, in opening the proceedings, said: Gentlemen, the secretary will read the notice calling this meeting.

Mr. HESSE (the Secretary) read the notice, as above.

The CHAIRMAN then said: Gentlemen, a month ago, when the extraordinary meeting was adjourned until to-day, I stated that I thought—in fact, that I felt confident—that I should be able to-day to announce to you that the agreement with the Australian colonies had been signed. We have had a good deal of telegraphing during the month, and I am happy to say that this morning I received the following telegram from Colonel Glover:—"Berry, Burns, and self have all signed the agreement, so all is now complete. Hope this will be in time for general meeting. Documents posted to-day by Francisco mail." Now, before making any remarks upon the importance of this contract which has been made with the Australian colonies, I think it is better that I should ask the solicitor to read the agreement, and after you have heard it I shall make a few remarks, and then I shall be glad to hear from any shareholder his opinion of, or his views on, the agreement. I may say that Mr. Berry is the Prime Minister of Victoria, and Mr. Burns is the Postmaster-General of New South Wales. I may say that they both have been authorised by their respective governments to sign the agreement. The agreement is, of course, not perfected, though it is signed, and is virtually perfected. It must, however, be perfected in this country when the documents come to hand. I believe that the colonial representatives here will be authorised to sign the formal contract. Mr. Bompas will now read the agreement.

Mr. BOMPAS, the solicitor, accordingly read the Agreement, as follows:—

1. That the Company shall, subject to the approval of the Shareholders, contract with the Governments for the construction of a second cable, from Singapore direct to Banjoewangie, thence direct to Port Darwin, for an annual subsidy of 32,400*l.*, and shall sign the Contract and necessary conditions on or before 1st July, 1879.

2. That the subsidy shall be payable for a period of Twenty years, subject to the provisions hereinafter contained.

3. That the Company shall, throughout the whole of the period during which the subsidy shall be payable, maintain in full working order (the act of God or the Queen's enemies excepted) such second cable, and also its present lines of cable between Singapore and Batavia and Banjoewangie and Port Darwin.

4. That the Company shall, before such subsidy shall become payable, lay a second cable between Singapore and Penang, and thereafter in like manner maintain the same (the act of God or the Queen's enemies excepted), its first lines of cable between Singapore and Penang, Penang and Madras, and Penang and Rangoon, in full working order.

5. That the Company shall, in consideration of the subsidy hereby agreed to be paid, and whilst that subsidy is payable, allow a rebate for Government messages, hereinafter defined, exchanged between England and Port Darwin, reducing their own proportion of the charge to the extent of 50 per cent. upon the present rates, and on Press messages exchanged between England and Port Darwin, as hereinafter defined, will reduce their own proportion of the charge to the extent of 75 per cent. upon the present rate, provided that such reduction shall not be extended to any colony other than such as may contribute towards the subsidy.

6. That the Company shall complete and open for communication the second cable above mentioned between Singapore and Port Darwin, and Singapore and Penang, within eight months from the date of the signing of the contract, provided always that the Company shall not be held liable for any loss or damage which the Colonies may sustain in consequence of delay in completing the said cables in the event of such delay being caused by war, inevitable accident, or other contingency over which the Company can have no control.

7. That in the event of the Company completing and having the duplicate cables above mentioned open for communication within the period herein contracted for, the subsidy payable by the Governments shall commence and accrue four months after the signing of the contract; but the company shall not be entitled to any payment under this clause until the said cables shall have been actually completed and are open for communication, as above stated.

8. That the said subsidy shall be payable quarterly in London to the Company in sterling money, free of all deductions.

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9. That in the event of any total interruption in the communication between Port Darwin and Singapore, the subsidy shall cease *pro rata* for the period of such interruption, provided that if the interruption be caused by reason of war, or any such like cause, the subsidy shall continue, but the company shall be bound to restore such communication at the request and cost of the Governments, so soon as the war or other contingencies shall have terminated.

10. The Company shall at all times hereafter give priority in transmission through the said cables to all Government messages, Government messages being such as are exchanged between Her Majesty's Principal Secretary of State for the Colonies and the various Agents General on the one side, and the Governors or Chief Secretaries of the various Colonial Governments on the other, on matters relating to the administration of the Governments.

11. Press messages must be addressed to registered newspapers only, and shall be for *bonâ fide* publication in full; they must be in English, in plain language, and intelligible. No cypher, code, groups of figures or of letters or words of concealed meaning to be used.

12. The Company shall not, during the currency of the agreement, increase its own proportion of the charges for messages exchanged between Port Darwin and London beyond the rates provided for herein, for Government messages per word 2*s*. 10*d*., for Press messages per word 1*s*. 5*d*., for all other messages per word 5*s*. 8*d*.

13. That the Government shall have the right, during the currency of the subsidy aforesaid, to purchase the Company's cable lines and other property between Singapore and Port Darwin on equitable terms, to be fixed in case of difference by arbitration, twelve months previous notice to be given to the company of the intention to purchase this right, provided always that the right shall not be exercisable till the Company shall for five years have paid a dividend equal to 10 per cent. per annum, and shall for that period have passed 10 per cent. per annum to its reserve or other accumulated funds.

The CHAIRMAN then said: Now, gentlemen, you have heard the agreement, which has taken a considerable time to work into the shape in which it is now placed before you. The advantages of this agreement are, I think, very great to the Company. The Australian Governments, when we first laid our line to Australia, were not disposed to subsidise in any way. The first line was laid, as you know, by money raised in this country. The line was laid, and was successfully worked. The Australian Governments have found out the advantages of telegraphic communication with this country; for, during the interruptions which have, from time to time, taken place, and which have always been repaired, they found that it was such an interruption to business that they—perhaps the first time they have ever been harmonious—have agreed to act together in securing a second cable to Australia. Now, gentlemen, it is not because the single cable cannot do the work. The single cable at the present moment could do ten times the amount of work now passing over the line; but it was the certainty of having telegraphic communication that has induced them to have a second cable. No doubt, it is possible that even two cables may be broken; but two strings to a bow are more certain than one, and the Australian colonies have, therefore, agreed among themselves to a subsidy to the extent of 32,400*l*. a year for securing this additional cable. Gentlemen, the principal advantages in favour of this arrangement are, that the fear of competition which the Company has been threatened with ever since its foundation is removed, and the co-operation and support of the Australian Governments is secured. It will afford the public a more reliable and efficient means of communication, by which we may reasonably anticipate receiving increased traffic, and saving the loss of revenue we have hitherto sustained through cable interruptions, amounting during the last two years to 32,000*l*. The reductions for Press and Government messages are not expected to show any loss to the Company, as all the Press telegrams sent at the reduced rate must be forwarded in plain language, and, moreover, the various Australian newspaper proprietors state that they will telegraph four times as much as they do at present. The consequence, I believe, will be that we shall enormously increase the number of messages, and it is the only way that we can repay to the people of Australia the tax which must be imposed on them for the subsidy granted to us. They get daily a very large amount of news through the newspapers, and this brings them into contact with the mother country, and in exciting times like the present they will know every morning as much as we know here as to what is going on in India and elsewhere. It is proposed, therefore, to take authority to raise 660,000*l*. for providing the duplicate cables, and restoring the working capital expended in payment of the screw steamers *Sherard Osborn* and the *Agnes*. The last-named ship was originally paid for by the issue of debentures, which were paid off without being charged to revenue. The additional capital is made up as follows:—The cost of the *Sherard Osborn*, 45,000*l*.; cost of the *Agnes*, 20,000*l*.; a larger supply of spare cable to be kept in stock, Hulk at Singapore, and engineer's charges, 31,000*l*.—in all, 96,000*l*. In order that the 660,000*l*. shall not form a permanent charge upon the capital, we propose redeeming the whole of it by annual drawings in twenty years, when the subsidy ceases. For this purpose it will be necessary to set aside the sum of 20,600*l*. annually, but as this will doubtless be met by the saving of 16,000*l*. a year, to which I have referred, from loss of traffic by interruptions of the cable, and by the increase that may be reasonably looked for, the duplication will be carried out without any sacrifice on the part of the shareholders. In other words, gentlemen, we expect from our continuous traffic to save 16,000*l*. a year, and I think it is a very low estimate indeed when we say 4,600*l*. a year for additional traffic. Thus the thing will be carried out without any sacrifice on the part of the shareholders. You get the advantage of a duplicate cable, the interest upon the cost of which is paid by the Australian Governments, and I may mention incidentally that I feel very well satisfied that you cannot have for any very long period of time consecutive, certain, telegraphic communication without duplication. Now, the cables from Penang to Port Darwin will be 2,551 knots in length, of which 1,738 knots will be specially protected against the teredo, which has been our great enemy in those seas. This special protection will involve greatly increased expense in manufacture. The estimated cost is 535,000*l*. Now, I may just mention the average number of messages passing daily over the following cables. The number over the Madras-Penang section is 212. That cable is now duplicated and duplexed. Over the Penang-Singapore section the number of messages is 225, over the Singapore-Batavia 105, and we could carry twice as much; and over the Banjoewangie-Darwin section we carry now fifty messages; and I think you will admit that there is very great scope for increased traffic on that section, and that is the section which the Australian Governments are now having duplicated at their expense. Now, gentlemen, with these remarks, and as no doubt there are some gentlemen in the room who will wish to ask some questions, I will move the first resolution:—"That the agreement now read be and the same is hereby approved and confirmed, and the directors are hereby authorised to execute all contracts, and do all acts requisite for carrying such agreement into effect, with such modifications, if any, as the directors may determine."

The Right Hon. W. N. MASSEY, M.P.: I beg to second that.

Mr. BAINES here made some remarks relative to the amalgamation of the old companies. He also spoke on the subject of the proposed duplication, after which,

Mr. FORD said: Mr. Chairman and gentlemen, I should have been extremely sorry that a resolution of such importance, either for good or to the disadvantage of this company, should have passed without some expression of opinion on this side of the table [hear, hear]. Any person who has considered the position of this company for some time past must have felt that a duplication of the cable was absolutely necessary. It has been my unfortunate lot during the last few months to hear, upon the oath of most experienced and reliable scientific and engineering experts, their opinion as to what is the "life" of a cable, and when I consider the changes which have taken place upon that important factor as relating to cable property, more and more do I see the absolute necessity for placing every single cable company in a position to have an additional cable. Bear in mind, gentlemen, that this cable has now been in operation, I think, for a period of seven years, and I assure you that, according to the testimony of the experts in science and engineering, seven years is a considerable portion of the "life" of a cable. This company, I venture to say, has, from time to time, considered the advisability of duplicating its cable; but any shareholder, or any persons that know the position of this company, must be perfectly well aware that it would be impossible to raise the additional capital by issuing shares at par. The only mode, therefore, of providing that duplication would be by obtaining a subsidy from the Governments, or else by debentures in the nature of a mortgage on the property itself, if the shareholders did not undertake to do it by means of debenture. When I say that I represent practically the largest shareholding interest in this company—by far the largest interest—you may well suppose that, as a matter of important consideration to my constituency, I have made it a point of considering this matter most carefully. I have done so, and I venture to say that, considering the figures which have been placed before us by the chairman, unsatisfactory as they may be to the hon. shareholder, Mr. Baines, they are perfectly satisfactory to me, for this reason, that I see no other means of securing permanently the traffic of this company, unless by some such measure of support as that which the Australian Government has tardily given to us. Our endeavour was, first of all, to get this support from the Australian Government, and I think it would be ill-becoming for this company to have it go forth to that Government that the opinion entertained by Mr. Baines, whatever his interest, is entertained by the general body of shareholders. I venture to say that the opinion of Mr. Baines is not shared; on the contrary, I believe the measure is one which, while securing to this company permanency—as far as permanency of telegraph property can be secured—will also avert that competition which most unquestionably arises, and must arise, when there is only one cable. Bear in mind, gentlemen, what has been our loss, as stated by the chairman. The loss is something like 16,000*l*. a year. We all know very well, too, that to increase the facilities for traffic is to increase traffic itself; and I venture to say that the prognostication made by the hon. chairman of the increase of traffic is exceedingly moderate. For these reasons, as one of the largest, or representing the largest shareholding interest of this Company, influenced, therefore, as my interests materially are, by the dividends to be obtained, I give my unqualified adhesion to this scheme. I consider that the agreement read shows that the directors have fully considered the subject, that they have provided against every possible contingency, that our interests have been fully represented; and for these reasons I heartily concur with the resolution.

Mr. NEWTON, in reply to Mr. Ford's remarks as to the life of a cable, stated that there were cables which had been in existence over twenty years, and he believed when a cable was laid on a good bottom it would last for ever.

The CHAIRMAN stated that it had been proved that the sea, instead of destroying the gutta percha, had the opposite effect; it was only the iron wires that were affected; but in shallow water, where most of this company's cables are laid, this has not been experienced, as we have always been able to raise the cable for necessary repairs without the slightest difficulty, and I may mention that a cable was successfully repaired in 800 fathoms of water a few weeks ago which had been down sixteen years.

The CHAIRMAN then put the first resolution, which was carried unanimously. He then moved the following resolution—"That the directors be authorised to raise capital for the purposes aforesaid, and for the general purposes of the company, by the issue of debentures not exceeding 660,000*l*. nominal, bearing such rate of interest, and with such special or other security, at such price, payable or redeemable in such mode, and at such time, and generally upon such terms and in such manner, as the directors in their discretion may determine," which was seconded by Viscount MONCK.

The CHAIRMAN stated that it was intended to obtain the necessary capital by debentures, which he hoped would be raised at 5 per cent., considering the guarantee of £32,400 per annum from the Australian Government, and that they would not form a fixed charge, but would be redeemable within 20 years, during which period the subsidy lasted; but that the money was not expected to be required till the beginning of next year, by which time he hoped the money market would be in a favourable condition.

In reply to a question from a Shareholder,

The CHAIRMAN stated that the present shareholders would have the first offer of the debentures, and that they would be issued to them *pro rata*.

The resolution was then put, and carried unanimously.

Mr. FORD proposed a vote of thanks to the chairman and board of directors, which was seconded by Mr. BAINES.

The proceedings then terminated.

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NOTES.

BALTIMORE.—The Electric Light Company of Baltimore, Md., has been formed with a capital of 300,000 dollars to produce light, heat, and power by electricity.

WOOLWICH.—The Government has, we understand, decided to extend the electric light in the Arsenal. There is no doubt about its applicability for large spaces and large workshops of this character.

THE TELEPHONE.—The New York papers report that Mr. Edison has stated that he has made an improved receiver for his telephone, by means of which persons standing 15ft. from the instrument can hear a whisper uttered miles away.

A CHANCE FOR THE ELECTRIC LIGHT IN BROOKLYN.—Inventors of electric lights have been given an opportunity by the Brooklyn Board of Aldermen to demonstrate the practicability and economy of this method of illumination. That body has just authorised the publication of advertisements for proposals to light the city next year either with coal-gas "or other illuminating material."

EXTENSION OF THE ELECTRIC LIGHT.—Messrs. Shoolbred have lighted their extensive premises by means of the Jablochkoff light, and Mr. Whitely, of Westbourne-grove, is about to make the necessary arrangements for lighting up his establishment. We would ask all those who think of introducing the Jablochkoff "bougie" to consider carefully Mr. Shoolbred's paper read at the Society of Arts.

NEWSPAPER SCIENCE.—Dr. Werner Siemens criticises recent popular newspaper essays on the conversion of mechanical power into electricity, and the reconversion of the latter into mechanical power. He shows that, in common with others, he had pointed out the future importance of this principle for the production of light, the conveyance of motive power, and other technical purposes. But all this passed unnoticed until it was re-discovered by an American.

A PROMISING INVENTION (AMERICAN), IF TRUE.—A correspondent of the Boston *Journal of Commerce*, writing from Philadelphia, tells of an invention, which has been kept secret pending the procurement of patents, and which, with power derived from a spring like that of a clock, furnishes an electric light of great brilliancy. It is further reported that the whole apparatus occupies no more space than an ordinary lamp, that it can be sold for six dollars per lamp, and that the light itself will cost only one-half cent per hour.

THEORY OF MACHINES LIKE THAT OF GRAMME. — ANT. BREGUET.—If it is desired to obtain the best possible effect from a system constituted by a moveable circuit animated by a rotatory movement in a magnetic field, then, if this movement is caused by the passage of a current from a foreign source, the diameter of the points of contact should be displaced in the inverse direction of the rotation by an angle so much the greater as the intensity of the current is more considerable and the intensity of the magnetic field more feeble. If this movement is destined, on the one hand, to produce a continuous current in the apparatus, the same diameter ought to be displaced in the direction of the rotation.—*Comptes Rendus.*

THE EDISON ELECTRIC LIGHT.—At the time of the departure of the last mail from America Mr. Edison had his new machine-house for testing the electric light nearly finished. This experiment, including the cost of everything, will cost 20,000*l.*, and the *New York Sun* points to this as a proof of the faith in the practicability of the invention. The same paper states that the price of the shares in the Edison Company has gone up. The well-known firm of Fabri and Chancery have bought from the Edison Company the exclusive right to use the new electric light in South America, and, as the contract for the lighting of Rio de Janeiro expires shortly, it is expected that that city will be the first in South America to be lighted by electricity. Mr. Edison says that he does not use carbon, and that his light does not burn itself out. He patented all the discoveries he made in his experiments both in England and America. The total cost of his electric light patents would amount to 3,500*l.* He further states that he was getting four times as much light with the same force as he did when he began his experiments. He was making two improved machines, and he was satisfied that he could get three lights equal to an ordinary gas-jet for each horse-power with each old generating machine, and six with the new machines.

APPARATUS OF M. GROS FOR GIVING WARNINGS AGAINST SUDDEN FLOODS.—This apparatus, which is being experimentally tested, by order of the French Minister of Public Works, on the river Lot, in the Department of Aveyron, is an electrical instrument, or telegraph, indicating automatically, at any required distance down stream, any rise or fall of the water-level up stream. The object is to give to those who are located upon the river bank as much time as possible to guard against the floods and inundations which in certain localities so frequently follow from a sudden rise in the water-level, commencing near the source and extending, with more or less rapidity, downwards towards the mouth of the river. The arrangement appears to be very simple; a float, established at a given point up stream, actuating the indicating needle of a dial, through the intermediary of a voltaic battery, so as to exhibit at any given station the height of the water at that point. When the needle arrives opposite the word "*danger*" inscribed upon the dial, an alarum bell is rung in each of the riverside villages placed in communication with the central station, and gives timely notice of the approach of the flood. It is hoped that by this means such catastrophes as those which in 1875 happened at Toulouse and elsewhere, or those which have more recently happened in the departments of Haute Loire and Ardèche, may be avoided or, at least, greatly mitigated.

A REASON FOR THE USE OF THE ELECTRIC LIGHT.—One of the many reasons for looking with favour upon the introduction of the electric light is the belief that it will have no injurious effect on pictures, frames, and bookbindings. Gas has always been supposed to destroy book leather, but, in a recent letter to an American contemporary, Professor Wolcott Gibbs, of Harvard University, United States, says: "Some time since I made an examination of the binding of books in the Public Library supposed to be injured by the products of the combustion of coal-gas. I arrived at the conclusion that there was no sufficient evidence to show that

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such was the case. I have since made a careful examination of books in the Athenæum, College, and Astor Libraries, and have found precisely the same state of things. You are aware that gas has never been used in the College and Astor Libraries at all, and that in that of the Boston Athenæum gas is largely used in the reading-room, but not in the library proper. I found in each a large number of old books bound in calf which presented the same appearance as those which I saw at the Public Library. These were all old books, and all bound in calf. Mr. Wilson, binder to Little and Brown, and a man of large experience, told me that he was satisfied that the trouble was in the tanning of the leather and not in the action of gas, the older kinds of leather used by binders being of poor quality and badly tanned. I analyzed a number of samples of the leather in my own laboratory, and find no free acid whatever. On the whole, therefore, I see no reason to change my opinion in the matter."

THE CAPITOL AT WASHINGTON TO BE LIGHTED BY ELECTRICITY.—The following statement is published under date of Washington, Nov. 19th, 1878:—"Supervising Architect of the Capitol, Clark, intends at an early date to light the Capitol by means of an improved electric light, invented by Mr. Rogers, the electrician of the building, thus doing away with the old cumbersome system of gaslights. It is calculated that four of Rogers's machines will amply illuminate the Hall of Representatives, which service is now done by 1,300 gas-jets. The cost of the new light will be about ten cents an hour. Mr. Rogers's machine has been fully tested and found satisfactory. Its principal features are the placing of two long slender carbon points inside small tubes, converging at an angle of about forty-five degrees on the negative and two on the positive pole, of course opposite to each other. A constant distance between them is maintained by a gearing of weights and pulleys, while the contact of the separate points in each set during the combustion prevents the formation of the concave 'cup' on the positive and the stalagmite on the negative pole, thus ensuring a steady, non-flickering, even light of any duration that is desired. To obviate the glaring brilliancy of the electric light, Architect Clark will cause opal-tinted glass frames to inclose the machines. Opal-tinted glass will not only give a yellowish tinge to the illumination, but, as it has the property of preventing the passage of the chemical rays, will relieve the sensation of apparent heat that has hitherto been found objectionable in an intense light or a collection of lights. It is somewhat singular that an Englishman has invented precisely the same machine as Rogers, and at the same time, it having been patented in Great Britain just about the period of Rogers's in this country."

H. WILDE ON A NEW LAMP.*—In a former communication† to the Society, I directed attention to the fact, that when the electric light is produced from the ends of two carbon pencils placed parallel to each other, if the strength of the electric current, the thickness of the carbons, and the distance between them are rightly proportioned, the carbons will burn steadily downwards until they are wholly consumed, without any insulating material between them. To initiate the light by this method, it is necessary to complete the electric circuit between the carbons by means of some conducting substance, which volatilises on the passage of the current, and establishes the electric arc between the points. When a number of such lights are produced simultaneously from the same source of electricity, any interruption in the continuity of the current extinguishes all the lights in the same circuit, and each pair of carbons requires to be reprimed before the lights can again be established. This defect, as will be obvious, would cause great inconvenience when the lights are not easily accessible, or are at considerable distances apart. In the course of my experiments it was observed that when the electric circuit was completed at the bottom of a pair of carbons close to the holders, the arc immediately ascended to the points, where it remained so long as the current was transmitted. My first impression of this peculiar action of the arc was, that it was due to the ascending current of hot air by which it was surrounded. This, however, was found not to be the cause, as the arc travelled towards the points in whatever position the carbons were placed, whether horizontally or vertically in an inverted position. Moreover, when a pair of carbons were held in the middle by the holders, the arc travelled upwards or downwards towards the points, according as the circuit was established above or below the holders. The action was in fact recognised to be the same as that which determines the propagation of an electric current through two rectilinear and parallel conductors submerged in contact with the terrestrial bed, which was described by me in the *Philosophical Magazine*, August, 1868. In all the arrangements in general use for regulating the electric light, the carbon pencils are placed in the same straight line, and end to end. When the light is required, the ends are brought into momentary contact, and are then separated a short distance to enable the arc to form between them. The peculiar behaviour of the electric arc when the carbons are placed parallel to each other, suggested to me the means of lighting the carbons automatically, notwithstanding the fact that they could only be made to approach each other by a motion laterally, and to come into contact at their adjacent sides. To accomplish this object, one of the carbon holders is articulated or hinged to a small base plate of cast iron, which is so constructed as to become an electro-magnet when coiled with a few turns of insulated wire. The carbon holder is made in the form of a right-angled lever, to the short horizontal limb of which is fixed an armature placed over the poles of the electro-magnet. When the movable and fixed carbon holders are brought into juxtaposition, and the carbons inserted in them, the upper parts of the two carbons are always in contact when no current is transmitted through them. The contact between the carbons is maintained by means of an antagonistic spring inserted in a recess in one of the poles of the electro-magnet, and reacting on the under side of the armature. One extremity of the coil of the electro-magnet is in metallic connection with the base of the carbon holder, while the other extremity of the coil is in connection with the terminal screw at the base of the instrument from which it is insulated. The coils of the electro-magnet are thus placed in the same circuit as the carbon pencils. When the alternating current from an electro-magnetic induction machine is transmitted through the carbons, the electro-magnet attracts the armature and separates the upper ends of the carbons, which brings them into their normal position, and the light is immediately produced. When the circuit is interrupted, the armature is released: the upper ends of the carbons come into contact, and the light is produced as before. When several pairs of carbons are placed in the same circuit, they are, by this arrangement, lighted simultaneously.

* From the Proceedings of the Manchester Literary and Philosophical Society, November 26, 1878.

† See *Elect.*, vol. ii., p. 31.

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SIEMENS BROTHERS' DYNAMO-ELECTRIC LIGHT APPARATUS.

In a series of experiments on magneto and dynamo-electric machines, conducted for the Trinity House by Dr. Tyndall and Mr. Douglas, M.I.C.E., the Holmes, Gramme, and Siemens machines were compared, and the Siemens machine was found to be the best. It was, in consequence, adopted for the lighthouse by the Trinity Board. Six of the complete apparatus are now erected at the Lizard.

Dr. Tyndall says: "I entirely concur in the recommendation of Mr. Douglas, that the Siemens machine recently tried at the South Foreland be adopted for the Lizard. From the first I regarded the performance of this handy little instrument as wonderful. It is simple in principle, and so moderate in cost that a reserve of power can always be maintained without much outlay. By coupling two such machines together a great augmentation of the light is, moreover, obtainable."

The Principle of the Machine.

When a closed electrical circuit is moved in the neighbourhood of a magnetic pole, so as to cut the lines of magnetic force, a current is generated in the circuit, the direction of which depends upon whether the magnetic pole is N. or S.; it also depends on the direction of motion of the circuit, and, according to the law of Lenz, the current generated is always such as to oppose the motion of the closed circuit.

All magneto-electric and dynamo-electric machines are based on the principle stated above, and are subject to many modifications.

The name *dynamo*-electric machine is given to a certain class of electromotors, because the electric current is not induced by a *permanent magnet*, but is accumulated by the mutual action of electro-magnets and a revolving wire cylinder or armature. It is found that, as the dynamic force required to drive the machine increases, so also does the electric current; it is, therefore, called a dynamo-electric machine.

tent of two-thirds of its cylindrical surface by curved soft iron bars NN_1, SS_1.

The curved bars are the prolongations of the cores of the electro-magnets E E, E E. They are held firmly together by screws to the sides or bottom of the cast-iron frame of the machine, making it compact and strong.

The coils of the electro-magnet form with the wires of the revolving armature one continuous electric curcuit, and, when the armature is caused to rotate, an electric current (which at first is very feeble) is induced by the remanent magnetism in the soft-iron bars and directed through the collecting brushes into the electro-magnet coils, thus strengthening the magnetism of the iron bars,* which again induce a still more powerful current in the revolving armature.

The electric current thus becomes stronger and stronger, and the armature, therefore, revolves in a magnetic field of the highest intensity, the limit of which is governed by the limit of saturation of the soft iron.

At each revolution the maximum magnetic effect upon each convolution of the armature is produced just after it passes through the middle of both magnetic fields, which are in a vertical plane passing through the axis of the machine (*i.e.* N_1 S_1 in fig. 1). The minimum effect is produced when in a plane at right angles to it, *i.e.* horizontal.

According to the law of Lenz already referred to, when a circuit starts from a neutral position on one side of an axis towards the pole of a magnet, it has a direct current induced in it, and the other part of the circuit which approaches the opposite pole of the magnet has an inverse current induced in it; these two induced currents are, however, in the same direction as regards circuit. A similar current will also be induced in all the convolutions of wire in succession as they approach the poles of the magnets.

These currents, almost as soon as they are induced, are collected by terminal rollers or brushes B, usually the latter, placed in contact with the commutator in the position which gives the strongest current. The position giving the strongest current gives also the least spark, so that when there are no sparks at the

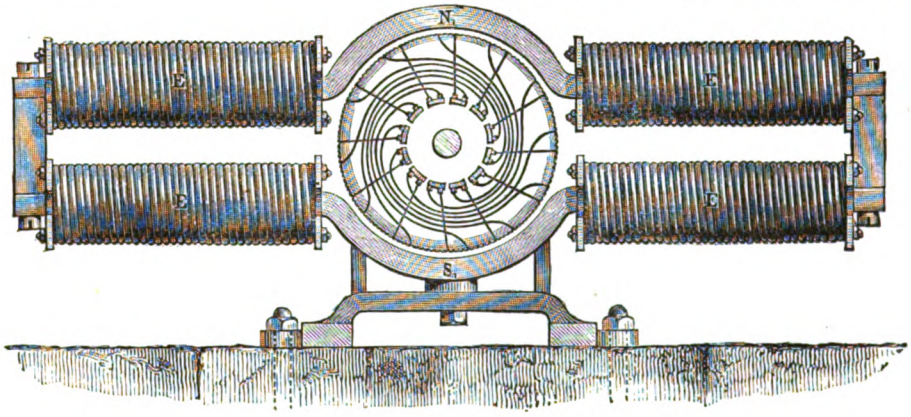

Fig. 1.

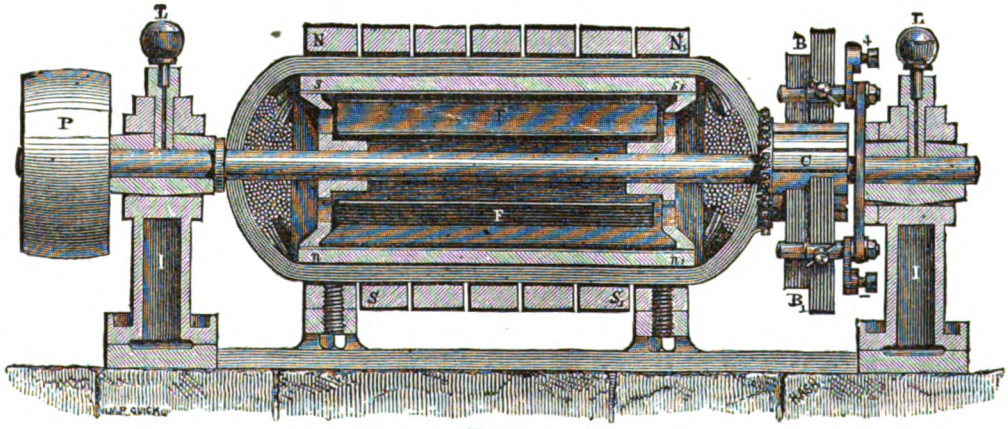

Fig. 2.

In the machine to be here described, of which fig. 1 is a part elevation and fig. 2 a longitudinal section, the electric current is produced by the rotation of an insulated conductor of copper wire or armature coiled in several lengths, say 8, 12, 16, &c., up to 28, and in several layers, longitudinally, upon a cylinder with a stationary iron core *n n' s s'*, so that the whole surface of the armature is covered with longitudinal wires and closed at both ends, as in fig. 2. This revolving armature is enclosed to the ex-

commutator the best lighting effect is produced. Fig. 3 shows position of brushes when the armature revolves in the direction indicated by the arrow.

The circumference of the revolving armature is divided into an even number of equal parts, each opposite pair being filled

* In wrought iron there is always some residual magnetism; there is, therefore, no necessity to start the magnetism with a permanent magnet.

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with convolutions of insulated wire wound parallel to the axis of the armature.

The ends of these wires are brought to a commutator and connected to the segments either by screws or by soldering.

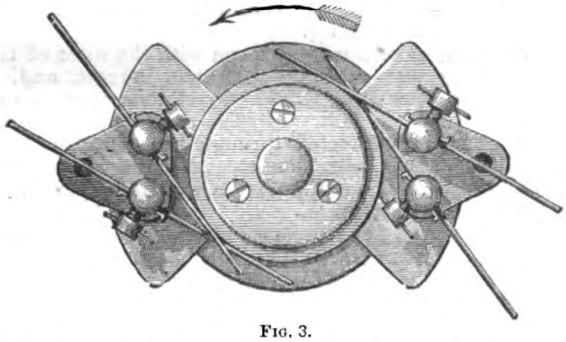

Fig. 3.

The brushes collect the electric currents as they are induced; these currents being nearly constant and continuous.

The collecting brushes are combs of copper wire placed tangentially to the cylindrical commutator, and press lightly upon it with an elastic pressure.

Speed, Driving Power and Light Produced.

An increase of the armature speed produces a corresponding increase in the current produced, but not in the same proportion. The current increases more rapidly than the speed, and could be made to reach any intensity but for considerations explained below. With increase of current there is also increase of heat.

The speed for continuous work must not be too high, because the heat developed at high velocities might destroy the insulation of the coils of the electro-magnet. The speeds given for each machine (see Table) produce no such injurious heating effect.

The strength of the current is also influenced by the resistance of the electric lamp and its leading wires. With an electric lamp in a circuit of proper resistance the armature should revolve at rates given in Table. The heating will then reach its maximum, which is very moderate, in about three hours; after which there will be no further change.

Table.

Size.	Number of revolutions of armature.	Intensity of light in standard candles.	HP (actual) to drive.
Small.	1,000 to 1,100	1,200	1½ to 2
* Medium	600 to 850	4,000 to 6,000	3½ to 4
Large	360 to 400	14,000 to 20,000	6 to 7 HP

The intensity of the unassisted light is given in standard candles—10 grammes of stearine per hour.

Regulation.

From the fact that a closed circuit rotating in a magnetic field experiences resistance to its motion which a broken circuit does not, motive power to any extent is only required when the circuit is closed. An interruption of the current is, therefore, equivalent to removing the load from the motor, which, for mechanical reasons, may be injurious to it, and, for electrical reasons, to the dynamo-machine.

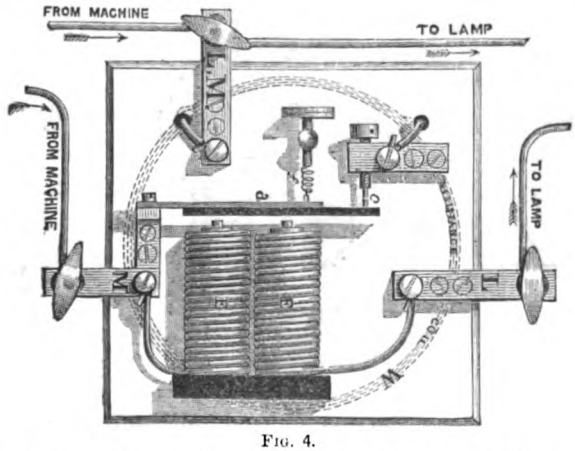

Fig. 4.

The sudden interruption of the circuit of the large machine produces an electric tension so dangerously high as to strain or destroy the insulation of the machine. When contact is again made after such interruption, the increase of speed from the interruption causes a momentary current of great intensity, accompanied by sparks at the commutator.

In order that the light may be quite steady, the speed should be as uniform as possible. Too high an increase of speed, such as may result from temporary extinction of the light, ought never to be permitted. The motor should, therefore, be provided with a good and sensitive governor, that will keep the speed perfectly uniform however the steam and load may vary. A large and heavy fly-wheel is also very useful in keeping the speed nearly uniform during change of load.

Although the circuit, when the machine is in full action, should never be suddenly interrupted, interruption arising from the extinction of the light is *not* dangerous, because it is always preceded by a decrease in the strength of the current. When it is desired to divert the current into another circuit, it is advisable to stop the machine. Although in practice with the smaller machines this is rarely done, with the larger machine it is necessary.

Self-acting Shunt.

For great security, especially with the large dynamo machine or with the two medium size coupled together, where the electric current is strong and the light equivalent to about 14,000 candles, it is advisable to insert in the circuit a self-acting shunt.

This is placed between the lamp and machine, and connected to both leading wires. Its principle is as follows:—

The terminal M (see fig. 4) is joined by a short connecting wire to one terminal of the machine. The terminal L M is connected to the remaining terminal of the machine, and also to one of the lamp terminals.

The terminal L is connected to the other terminal of the lamp.

The shunt contains a small electro-magnet E mounted upon a square wooden slab, or base-board, with its armature *a*, a contact *c*, and, below the slab, a resistance coil W, which is equal to the resistance of the electric arc of the light (say = 1 *s.u.*)

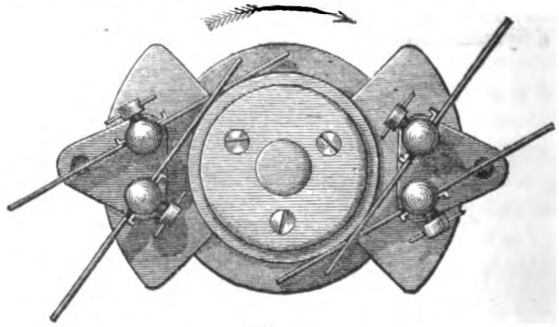

Fig. 5.

As long as the lamp is burning well, the current circulates in the coils of the electro-magnet, and, the armature *a* being strongly attracted, there is no contact at *c*. The resistance coil W is, therefore, not in electrical circuit. When the light is extinguished the current in the coils of the electro-magnet ceases, and the armature is withdrawn by the spring *f* making contact at *c*. This offers to the electric current a path through W of equal resistance to that of the lamp, and the current is subjected to scarcely any change, so that the motor has practically no cause to alter its rate.

When the carbon points of the lamp again touch, the electric current returns to them, breaking contact at *c*, re-establishing the former conditions.

Direction of Rotation.

The armature may revolve in either direction. If it becomes necessary to drive it in the opposite direction to that for which the machine has been made, it is only necessary to reverse the brushes, placing their points in the direction of motion, and to change two of the wire connections, which operations can be effected in a few minutes. Fig. 3 shows the position of brushes for one direction of rotation, and fig. 5 that for the other.

(to be continued.)

Duplexing the Atlantic Cable.—Mr. J. B. Stearns is now at Valentia, having just crossed over from Heart's Content, where he has been carrying on a series of experiments with the object of duplexing the Atlantic cable. He has been so successful that he expects to have finished his work at the cable by the end of the year. As long ago as last May he obtained a perfect balance on the mirror, but the recorder is more difficult to work duplex than the mirror. He has now, however, succeeded in obtaining a balance with the recorder, which, from specimens brought to England, appears practically perfect.—*Journal of the Society of Arts.*

* This is the size referred to as the small Siemens Machine in the Trinity House Report.

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MR. HERRING'S IMPROVED PRINTING INSTRUMENT FOR TELEGRAPHIC WORK.

The following description will, we trust, enable our readers to obtain a fair idea of the instrument we have several times recently referred to in our pages. We believe we are correct in stating that Mr. Herring was led to experiment in this particular direction by an intimate knowledge drawn from a long experience of paper-making machinery. The ordinary Morse slip is well known to most of us, and the narrow ribbon of bluish paper does not always recall pleasant sensations. The system there adopted in printing is the horizontal one, thus: — — —

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THE PROGRESS OF TELEGRAPHIC COMMUNICATION WITH OUR COLONIES.

Year by year the necessities of trade make deeper the impression that one of the greatest gifts of science to mankind has been the "Electric Telegraph." As civilisation advances, as the world becomes more evenly populated, as the science of exchange of the natural products of one zone for those of another becomes better known, and as the principle of division of labour becomes more developed, the greater will be the value of a rapid and reliable means of intercommunication. The men who are working now, working, too, in the face of opposition and of ridicule, these are the men who will receive the greatest thanks of the next generation, as having laid a surer foundation than all the agreements and treaties of politicians to a millennium of peace and national friendship. We are glad, then, to call attention to the great advance made to ensure telegraphic communication with our antipodean colonies. Some historians cause us to look to North-West India as the cradle of the families of nations which now sway the destinies of the Earth; they point out how slowly and surely power and wealth have travelled westward. We are shown the rise and downfall of the grand Assyrian and Median dynasties. We are shown how then Greece moved in the van, only, however, to give place to Rome. The more modern centuries have witnessed Spain all powerful, then powerless. Now, the islands of the Western parts make their influence felt in every country of the world, and, undoubtedly, the tendency of power is to gravitate to that young but vigorous nation which wields power over the greater part of North America. If, as ages roll onward, the cycle of power should continue its round, then our Australian colonies may play the part in the world's history that the mother country is doing now. Be it so. As yet, we see these colonies in their babyhood, undeveloped, but waiting and inviting the services of a race who comes to see and to conquer.

It is, perhaps, an inducement to many people to learn something about telegraphy that its history is so short, and that no great amount of time has to be spent before one has the history at his fingers' ends. The history is, indeed, a marvellous one, and especially is this the case with submarine telegraphy, and yet few seem to notice the wonder in our midst. One of the pioneers in telegraphy, writing in 1850, says:—"On 11th December, 1849, to the great astonishment of the merchants and bankers of Paris, three gentlemen appeared on 'Change in that city at half-past one p.m., having with them 150 copies of *The Times*, printed and published in London on the morning of the self-same day; and not only did *The Times* contain the Paris news up to *noon of the previous day*, but actually the closing prices of the Paris Bourse of the *previous evening*. The electric telegraph contributed in no small degree towards the accomplishment of the feat. At eight minutes past one a.m. the despatch of 324 words, and the Bourse prices, equal to 55 words, were delivered into our charge at Dover, having been conveyed thither from Calais in the ordinary mail boat. In exactly *thirty-two* minutes, viz., at forty minutes past one, a correct copy of both these documents was handed in by us to *The Times* Office in London. The despatch occupied us eighteen minutes, being at the rate of 17 5-6 words per minute, the Bourse prices two minutes. In respect to the latter the rate is high, because the larger portion is anticipated, the mere fluctuations being all that is new. There was nothing extraordinary to us in this, quickly as it was accomplished; indeed, on the following morning the writer in London was fairly beaten by the telegraph—the words were read off faster than he could make a clean copy of them."

These results were and are astounding, but everybody now refuses to be astonished. We do not remember to have seen any reference to some of the recent work of the Eastern Telegraph Company. Take, for an example, the despatch published by the *Daily News* to the effect that General Roberts had gained a victory at the Peiwar Pass. This despatch was started from Lahore, we believe, about eleven o'clock in the day, and delivered in London at eight o'clock the same morning, beating the sun by about three hours. We are so accustomed to see this sort of thing that we take no notice of it, and are apt to grumble if our morning paper does not contain a batch of telegrams from almost every civilised country in the globe. It is the submarine telegraph that enables us to obtain these results, and, as we say, this telegraph is but a thing of yesterday. So far as we know, the gentleman above referred to, Mr. C. V. Walker, was the first to

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carry out any experiments in this direction, on Jan. 10, 1849, or nearly thirty years ago, and, in describing the experiment, he says, "The day will assuredly come, but not just now, when this embryo invasion of Neptune's domain shall become a practical reality." How true the foresight! for in less than thirty years from the time of the experiment we have in practical work more than thirty thousand times the two miles of cable used on this memorable occasion.

"I must confess," says Mr. Walker, in his recital of his experiment, "I felt a little uneasy at having called so many witnesses so far from their homes to an experiment which could be but partially tested in advance, and the first perfect trial of which would be made publicly. I knew that a slight defect of insulation would not have marred the experiment had the two miles of submerged wire alone been in circuit, but, when to this was added the eighty-three miles of wire between the coast (Folkestone) and London, I was aware that flaws would be fatal. All being ready, I took the handle of the instrument and made the letter L, the call for London; the acknowledgment of the call was instantaneous, and at forty-nine minutes past noon the first telegraph despatch passed beneath the British Channel in direct course to London; it was: 'Mr. Walker to Chairman—I am on board the *Princess Clementine*. I am successful.'" How much these last three words contain many of us know, and at the same time realise how inadequate language is to express what is felt on such an occasion.

We have not the slightest doubt but that the success with the 2,551 knots required for the duplication of the cable from Penang to Port Darwin will be as great as was that of Mr. C. V. Walker at Folkestone; yet it must not be taken for granted that the work has no difficulties. The manufacture of a submarine cable is one of the most delicate nature, requiring incessant testing and constant and continued supervision over every particular. The anxiety does not cease from the instant that the manufacture is commenced till the time the whole is placed in the position in the sea-bed it is destined to occupy. The least hitch at any one point is fraught with the greatest danger. Nor is the anxiety or vigilance of those connected with cable work put aside when the cable is laid. Other enemies then commence their attacks, and, although science is ever seeking something new to guard against all and every enemy, it must not be said that science as yet can boast of absolute victory. Under these circumstances, we think that no one will refuse a hearty God-speed to those whose energy and perseverance will ere long add another link to the means of communication with Australia.

THE EDISON ELECTRIC LIGHT.

The *Daily News* of Thursday, December 12th, contains a telegram from America, relating to the Electric Light of Mr. Edison. It is singular that none of our daily papers credit the scientific press of England with ordinary scientific knowledge. The "facts" published by the *Daily News* have long been known in England. We were the first to give the direct clue to the work of Mr. Edison in our issue of October 26th, but were compelled to refrain from mentioning the materials used by him, because of compromising his patent. Since then we have frequently commented upon the work of Mr. Edison, and have given more or less details of the materials he uses, and expressed our opinions as to their value. The following is the telegram referred to:—

"Mr. Edison authorises the statement that his light is produced by the incandescence of an alloy of platinum and iridium. The conductor is not an ordinary coil, but a peculiar arrangement of the metal, whereby, in accordance with a new discovery of his in connection with radiant energy, a much weaker current is made to generate a given light than if a single spiral were used. By slight modifications in the shape of the conductor he has obtained from one cell of a Daniell battery a light strong enough to read by. A simple adjustable apparatus attached to each lamp regulates the amount of electricity it shall draw from the main current, and makes it entirely independent of any changes in the strength of the current as well as of all other lamps in the circuit. That portion of the current which is used for the regulator is also made to serve in the production of the light. A part of Mr. Edison's device for compensating for loss in subdivision consists apparently in the utilisation for illuminating purposes of the resistance of the regulator, and of all other resistance outside of the main conductor, and part in the peculiar form of the conductor."

THE LAW OF CURRENT IN DYNAMO-ELECTRIC MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question whether Ohm's law is applicable to dynamo-electric circuits has recently been raised; and some confusion prevails as to the real points at issue. Some investigators are finding out for themselves two facts which I have never tired of repeating for the last twenty years, viz., that there is in nature no dynamic force varying simply as the number of cells in series of a battery, or corresponding with what is defined as electromotive force, and no inertia varying according to what is defined as electrical resistance. It is observed, also, that the effects of varying these "current elements" are very different in the two cases of the dynamo-electric and the voltaic circuits. Still, this does not mean that the law of Ohm is incorrect as a law of phenomena—an expression indicating a necessary relation but, from a physical point of view, as empirical as other mathematical laws in which causation is lost sight of.

In the case of any electromotor the equation $I = \frac{E}{R}$ is strictly applicable.

In the Voltaic Battery, however, a variation of R does not necessarily affect E, which is altogether independent of such variation when this occurs in the external portion of the circuit. Thus, we have generally $I \propto \frac{1}{R}$, or current varies inversely as the resistance in circuit.

Again, a variation of E does not *necessarily* affect R; and, when the external resistance of the circuit bears a high ratio to the battery resistance, a variation of the electromotive force, from E to E_1, an addition to, or diminution of, the number of cells in series, causes the current to vary approximately in the ratio $\frac{E_1}{E}$.* Thus, in the case of a telegraph circuit, for instance, we have, approximately, $I \propto E$. On the other hand, *in the dynamo-electric machine*, converting into electrical work a given horse-power, $I \propto \frac{1}{\sqrt{R}}$, since, the ratio $\frac{E^2}{R}$ being constant, $E^2 \propto R$, $E \propto \sqrt{R}$, and $\frac{E}{R} \propto \frac{\sqrt{R}}{R} = \frac{1}{\sqrt{R}}$. Thus any variation of R in this case necessarily affects E.

Again, any variation of E necessarily affects R; and, the product E I being constant, we have $I \propto \frac{1}{E}$, a somewhat startling result, which, to some observers, has appeared contradictory to the law of Ohm. With this, however, it is in perfect accord—in effect, since $E \propto \sqrt{R}$, $R \propto E^2$, and $\frac{E}{R} \propto \frac{E}{E^2} = \frac{1}{E}$; or, when E is varied, *the current varies inversely as the electromotive force, because the resistance varies as the square of this value.*

It will be seen that $R \propto E^2 = \frac{1}{I^2}$, and that *the same quantity of work will be done by the current whatever may be the resistance in circuit.*—I am, &c.,

DESMOND G. FITZGERALD.

* Accurately, the variation in any case is determined by the ratio $\frac{E_1 R}{ER + E\rho}$, where ρ is the resistance of the cell or cells added or subtracted. Thus,

$$\frac{E}{R} \times \frac{E_1 R}{ER + E\rho} = \frac{E_1}{R + \rho}.$$

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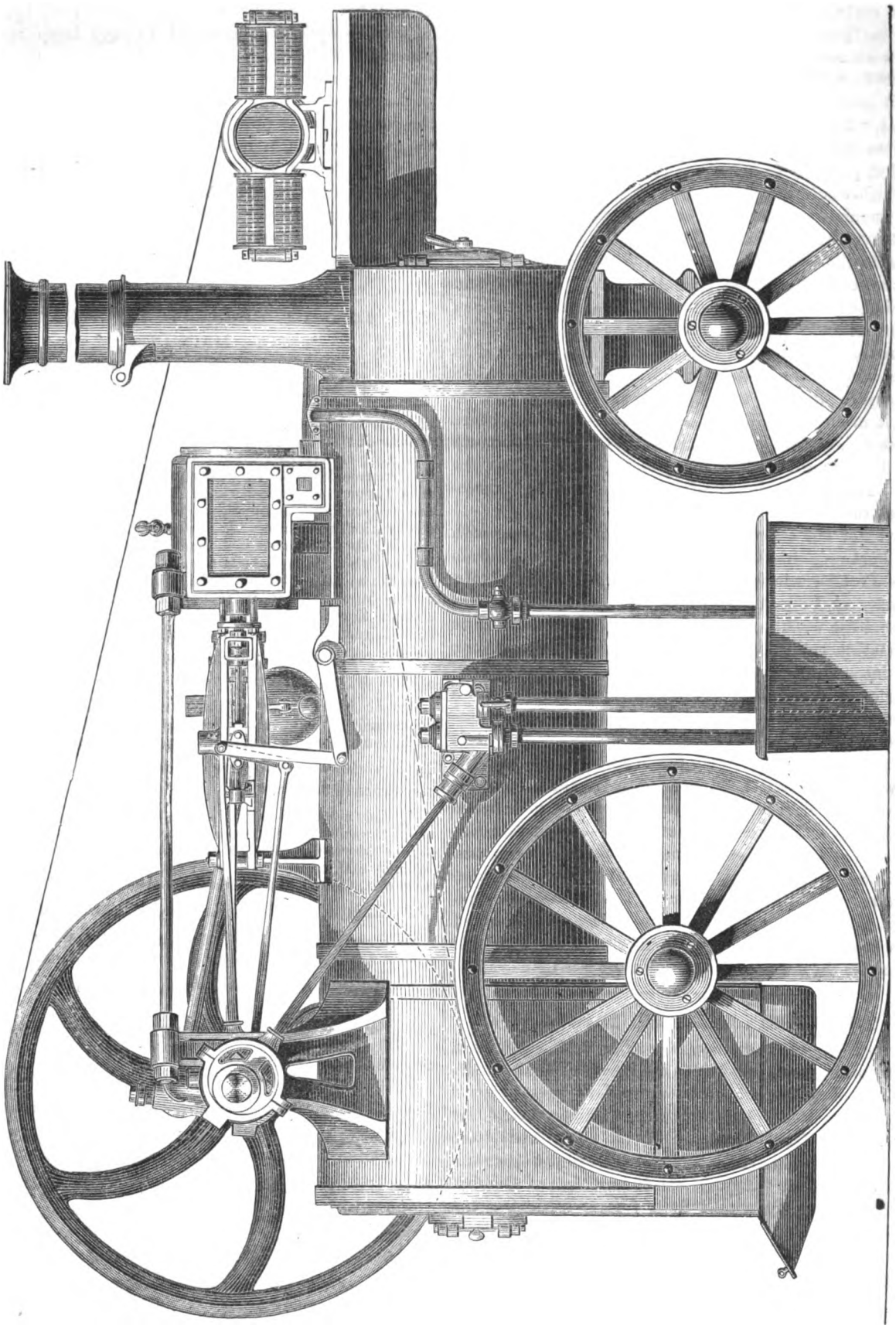
THE MOTIVE POWER TO DRIVE DYNAMO-ELECTRIC MACHINES.

Many of the visitors at the meeting of the Society of Arts on December 4 were too eager to call attention to what they termed a failure of the electric light. Dr. Siemens, however, in a very few words, pointed out that the varying intensity of the light was not due to any fault of the electrical apparatus, but to the great difficulty experienced in obtaining a constant steam pressure, and therefore a steady revolution of the machine generating electrity. A great objection urged against the electric light has been its unsteadiness, sometimes too brilliant, at other times seemingly upon the point of "going out." The attention shown in the manufacture of the carbons has gone a long way to get rid of this fault, and with the perfecting of the homogeneity of the carbons, we realise more clearly the failure in steadiness of the driving power. Broadly speaking, the quantity of electricity generated depends upon the number of tubes of force cut in a given time. If, then, the machine fluctuates between, say 600 and 1,000 revolutions a minute, the quantity of electricity generated in the time



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fluctuates proportionally, as does also the intensity of the light. The success, then, of the electric light depends not only upon the efforts of electricians, but also upon the efforts of mechanicians. Assuming, for the time, that in the majority of instances steam will be employed as the motive power, we see that the electrician must consider his engine and boiler as well as his electrical apparatus. He will have to take into account whether his engine is used solely for driving the dynamo machine, or whether his apparatus is merely an addition to that already driven from the same source. Everyone who has been into a machine shop knows the great strain that is thrown upon the engine as a number of tools are thrown into gear, and knows also that great efforts have been made to regulate perfectly the admission of steam, or, in other words, the pressure according to the work to be performed. If the engine is employed only to drive the electric machine, there will still be variations in the resistances, and thus in the pressure required. Several of our largest manufacturers of engines have already given attention to this subject, and from various directions we hear of machines specially adapted to the driving of electric machines. We shall in this and future numbers briefly describe these engines, and, after certain experiments are completed, hope to give the results obtained. For electric light purposes it is better in all cases to employ a small separate steam engine, unless, indeed, the engine in the works is far above the power required to drive the machinery, and is practically unaffected by the putting in or out of gear any of the machines.

Messrs. Ransomes, Sims, and Head, of Ipswich, have devoted a considerable amount of attention to engines adapted to electric light purposes. The firm has supplied engines for lighthouses in Russia and New Zealand, &c., and during the late loan exhibitions at South Kensington one of their engines was used. Recently a portable engine, specially designed for the purpose of driving dynamo machines, has been constructed. As will be seen from the illustration on the opposite page, the machine to be driven is placed on a platform in front of the smoke box. If a generator and distributor are used, then another fly-wheel can be attached to the shaft, and the requisite pullies obtained. The design here shown can easily be modified so that the position of cylinder and crank-shaft can be interchanged if necessary, and the bracket supporting the dynamo machine fixed to the side of the fire-box. These machines are made of from 4 to 12-horse power, and, if necessary, the wheels can be taken off and pedestals substituted, thus, in fact, combining the advantages of a portable and a stationary engine. In order to obtain heat regularly, Messrs. Ransomes recommend that their patent automatic governor expansion gear should be fitted to each engine, and the 20-horse power engine being prepared for the experiments in London to be carried out under the auspices of the Board of Works is to be thus fitted. The gear* consists of two small eccentrics fitted on the crank shaft, fitted with straps and rods in the usual manner. The ends of the rods are connected together by a solid link, which slides in a block carried by the rod of the cut-off valve. The weigh shaft and supporting rod form the connection between the link and the governor, which is on the Porter principle. The action of the whole is as follows:—The eccentric, which is attached to the lower end of the link, is fixed at such an angle in relation to the crank as to effect an early cut-off, whilst the eccentric attached to the top of the link is set so as to allow a late suppression of the steam. When the load on the engine is diminished or increased, the governor instantly revolves above or below its normal speed, and, by the rising or falling of its arms and balls, it shifts the link, and brings the expansion valve more or less under the influence of the early or late cut-off eccentric, thus regulating the supply of steam to the altered load until the engine again makes its proper number of revolutions per minute.

MR. HERRING ON THE POST OFFICE AND POLITICS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Although "J. L." is evidently a Post Office official, I should probably have left his anonymous letter unanswered if you had not appended the well-merited rebuke to him that "an Englishman's privilege concerns the man of science quite as much as the man of politics." "J. L." says: "It is edifying to learn that all British subjects have a right to petition the Crown; but, unless the charter of liberty also provides that every such petition shall be acceded to, the information is of small value." I need not repeat remarks contained in my former letter, which set forth all the conditions required by the Secretary of State having been satisfied, one of which being his approval of my petition as "a complaint of unfair treatment by one of the departments of Her Majesty's Government." "J. L.," however, requires information "touching my right to petition the Crown," and I therefore ask space to make a few additional remarks.

The right of the subject to petition the Sovereign is indisputable. It was embodied in the Declaration of Rights presented on behalf of both Houses of Parliament to the Prince of Orange on his elevation to the Throne, and subsequently obtained a statutory force as one of the enactments contained in the Bill of Rights. The staunchest upholders of the Crown and the Constitution cannot deny this, unless they are prepared to undo the work of the Revolution of 1688, and sweep away the very corner-stone of the British Constitution.

But, if the subject possesses the right to petition the Sovereign, it cannot mean the barren right of addressing a complaint, the substance of which is to be communicated by a Minister to the Sovereign, and then, by the latter, to be referred to some Department of State, to deal with it or not according to its own pleasure. The right of petitioning the Sovereign conveyed the idea of being able to make the Sovereign personally cognisant of an alleged grievance, and to obtain, if not redress, at least a personal judgment on its merits.

In order that no doubt may exist upon this point, let us see what actually took place before the Declaration of Rights was drawn up, and what led to the particular clause to which I refer being introduced into that celebrated document.

James II. affected, by his own personal authority, to suspend the penal laws affecting Nonconformists, and also to abrogate all statutes imposing any religious test as a qualification for any public office. This he did by a Declaration of Indulgences. He went a step farther; by an Order in Council he commanded that the Declaration should be read in all churches and chapels throughout the kingdom, on two successive Sundays. In London, the first Sunday named for reading the Declaration was May 20, 1688. On Friday, the 18th, a meeting of prelates and other clergy of the Anglican Church was held at Lambeth Palace, and it was then resolved to draw up a petition to the King, humbly praying him to rescind the Order in Council, and not to impose upon the clergy a command to read in the House of God a Declaration which was notoriously illegal. The petition was drawn up by the Archbishop of Canterbury, and signed by him and six bishops. No time was to be lost. In less than forty-eight hours the clergy would have to elect to obey or disobey the King's command. Had the bishops lived at the present day, they would have been obliged to forward their petition through the Home Office, and would have probably received an answer in a week's time, stating that by the King's commands the petition had been referred to the Privy Council Office, as the department from which the Order had issued.

The bishops, however, lived in other times, and took a readier course. They proceeded to Whitehall, and sought and obtained an audience of the King. He read the petition, and was furious. He charged the bishops with rebellion, refused to rescind the Order in Council, and by his command the prelates were prosecuted for publishing a seditious libel, the libel being the petition which had been placed in the hands of the King. At the trial, it was contended on the part of the Crown that none but the Houses of Parliament had the right of petitioning the Sovereign. The trial resulted in the acquittal of the bishops; but, a few months later, when James had fled from England, the Lords and Commons, before giving the crown to the Prince of Orange, with a lively recollection of what had so recently taken place, put on record in the Declaration of Rights the indisputable privilege of the subject to petition the Sovereign, and to be held harmless for any matter such petition might contain.

It may, perhaps, be said that personal authority was more largely exercised by William III. and the earlier Sovereigns of the House of Hanover than at the present day, and that the principle of Ministerial responsibility is now more generally recognised than in the half century succeeding the Revolution. This is undoubtedly so; but Ministerial intervention has gone too far, and has literally robbed the Crown of one of its most precious prerogatives, and the subject of one of his surest safeguards against oppression.

This result has been brought about in part by the gradual establishment in this country of what is known as "the Cabinet," and in part by the growing disinclination of our Sovereign to exercise any personal influence in the transaction of public business. The Cabinet is a body which is entirely unknown to the British Constitution; its existence is unrecognised in the "Official Gazette;" its proceedings are unrecorded in the archives of the State. Its germ was formed in the reign of Charles I., but it was not until the time of William III. that the Cabinet became an important engine in the administration of the State. Its growth was watched with jealousy by those who desired to preserve the Constitution intact. For, according to the Constitution, the Sovereign is bound, in matters of State, to seek the

* "A Few Notes on the Portable Steam Engine." By J. Head, M.I.C.E.

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assistance and advice of the Privy Council, and, as a matter of fact, all proclamations and orders still emanate, as the law requires, from that body. The effect of the change, so far as the administration of the State is concerned, is that plans of Government are discussed and determined in the Cabinet, forming, as Hallam says, "part of the larger body, but unknown to the law by any distinct character or special appointment."

But what has been the result of this silent change in the Government of this country, as regards matters cognate to that which forms the subject of this letter? Let the great constitutional historian speak for himself:—

"I conceive (says he), though I have no means of tracing the matter clearly, that this change has *prodigiously augmented the direct authority of the Secretaries of State, especially as to the interior department.*"* Could a more striking illustration of the accuracy of this conclusion be given than that afforded by my case?

Referring to the results of the establishment of a Cabinet, Mr. Hallam says:—

"This, however, produced a serious consequence as to the responsibility of the advisers of the Crown, and, at the very time when the controlling and chastising powers of Parliament were most effectually recognised, it was silently eluded by the concealment in which the objects of its inquiry could wrap themselves." And he continues:—"It may be that no absolute corrective is practicable for this apparent deficiency in our constitutional security; but it is expedient to keep it well in mind, because all ministers speak loudly of their responsibility, and are apt, upon the faith of this imaginary guarantee, to obtain a previous confidence from Parliament which they, in fact, abuse with impunity. For, should the bad success or detected guilt of their measures raise a popular cry against them, and censure or penalty be demanded by their opponents, they will infallibly shroud their persons in the dark recesses of the Cabinet, and employ every art to shift off the burthen of individual liability."*

When the Bill of Rights was passed, Cabinet administration had not yet obtained any hold in the kingdom, and an attempt was made, ten years after the King's accession, to re-establish the ancient system, William pledging himself, on the formation of his new Privy Council, to seek its advice. It is therefore apparent that the right of petitioning the Sovereign presupposed that the King would deal with such petitions on their merits in the exercise of his royal prerogative, or, if the matters were of such great public concern as to need it, would seek the advice of his Privy Council before pronouncing his personal decision.

It may be said, however, that the subject matter of my petition was not of sufficiently grave importance to necessitate the summoning of the Privy Council, or even of that small section of it which is known as "the Cabinet," to enable the Sovereign to decide upon its merits. That it was of "grave importance," seeing that it brought serious charges against one of the most important departments of the State, cannot be denied. But my contention is that, if the Privy Council or the Cabinet were not consulted on the subject, as not being of sufficient gravity or public concern to necessitate their advice being taken, I was, by the Constitution, entitled to have the merits of my petition considered by the Sovereign in the exercise of her Royal prerogative. From no aspect of the case can it be said that justice was done me by referring my petition to the Postmaster-General, to be by him incontinently dismissed as undeserving of any attention whatever.

Moreover, I would ask "J. L." what the public gains by the neglect of the Post Office to attend to the Queen's commands? He seems to have forgotten the fact that I was silent until his chief, Mr. W. H. Preece, stated at the recent meeting of the British Association that "the monopoly in telegraphy possessed by the State had not checked improvement." I remained silent, in fact, until Mr. Preece went so far as to print his misleading paper on "Recent Advances in Telegraphy" in the *Journal of the Society of Arts*. This I felt it would be unfair to inventors to leave unanswered, and I therefore followed him with a paper on "Recent Obstructions in Telegraphy," which appeared the following week in the same journal.

"J. L.," speaking, I presume, for the Post Office *employés* generally, says: "We should be interested to know whether his (my) invention was or is a good one." Whether he intended it or not, that is just the question I want answered myself. He, however, betrays a fatal want of impartiality when, shortly after, he adds: "Speaking for myself, I am willing to accept Sir W. Thomson's and Professor F. Jenkin's dictum rather than Mr. Herring's disparagement of it." Let me assure "J. L." that I am not the man to speak disparagingly of any work of theirs without giving my reason for so doing. Up to the present time Messrs. Thomson and Jenkin have never met the referees appointed and paid to represent me, although I appointed them at the request of the Post Office. The trial of my instruments, under terms of reference signed on behalf of the Post Office and of myself, has never taken place, and has never been arranged to take place, although I repeatedly urged the matter before presenting the petition which appears to have given "J. L." and his friends so much offence. My solicitors also wrote to the Post Office and requested the authorities to fulfil their engagements. In one of the letters sent to the Post Office by my solicitors, and which letter has never been attended to, there are some remarks which "J. L." should become acquainted with before he expresses any opinion upon the unfinished work of Professor Jenkin. The following is an extract from the letter referred to:—

"On the 26th July, 1872, Professor Jenkin made a preliminary report addressed to both parties to the reference, which contains this passage:—

'It is very desirable that an automatic Wheatstone's sender should be arranged to send slips with actual messages, so that they may be recorded by Mr. Herring's Instrument. No trials can be quite satisfactory which do not exclude the imperfections of sending.'

"We find among the papers in this case the following minute:—

'Nov. 18, 1872. Write to Mr. Fleeming Jenkin with reference to his preliminary report on Mr. Herring's Telegraph Instrument, and request to be informed whether he is still of opinion that the Department should make, at its own cost, an automatic sender for the purpose of further testing Mr. Herring's Instrument. F. I. S.'

"We also find that Professor Jenkin wrote to Mr. Scudamore as follows:—

'In answer to your letter of the 18th, I beg leave to say that I think it unnecessary that an automatic sender should be made by the Department unless the officers of the Department think it desirable.'

"This letter of Professor Jenkin is manifestly inconsistent with the rules which govern the conduct of referees, and with the ordinary principles of justice, and it is necessarily fatal to the assumption of "a full and fair trial" which you would draw from the names of the referees. It comes to this, that one of the referees writes to one of the parties to the reference to inquire whether that party thinks it "desirable" that a step should be taken which the referee had previously declared "very desirable" for a satisfactory trial. In effect, the referee applies to one of the parties for directions as to the method of proceeding in the reference.

"A reference thus conducted would be an absurdity, and its result must be nugatory, and, accordingly, we find that Mr. Scudamore was sensible at the time that something more would be necessary to a satisfactory trial.

"On 19th December, 1872,

'Mr. Scudamore promised that if Mr. Herring wished a further trial of the Instrument after Messrs. Thomson and Jenkin had made their report he would give his consent.'

"We have before us Mr. Herring's memorandum of his interview with Mr. Scudamore on that day, and Mr. Scudamore's letter of the next day, admitting that the memorandum 'is accurate as far as it goes.'

"On 15th October, 1873, an interview was held at the Post Office between Mr. Scudamore and Mr. Herring, Mr. Law and Mr. Patey also being present.

"The notes of this interview, sent by Mr. Scudamore to Mr. Law, are before us.

"Mr. Scudamore begins the conversation by expressing his desire to come to a settlement as to the 'really important questions' that are pending. He says:—

'The first (of these important questions) is as to what further trial there shall be of Mr. Herring's Instrument; that is certainly the most important. I consented on a former occasion that there should be another trial, and I am quite ready to act up to my promises made on that occasion. I said then that I would not incur any further expense on behalf of the Department by employing Professors Thomson and Jenkin again. I do not want to bring them to London on purpose to witness the trial or to take part in it. I have no doubt, however, that they will be in London again, and I shall have no objection to let them act on behalf of the Department then if Mr. Herring is willing, and meet any gentlemen he is disposed to appoint on his own behalf. . . . . .'

"The foregoing extracts show that Mr. Scudamore admitted that Mr. Herring was entitled, after Sir William Thomson and Professor Jenkin had made their report of 18th January, 1873, to a further trial, in the course of which those gentlemen should, at some convenient time, meet gentlemen appointed on Mr. Herring's behalf.

"This, then, is the 'full and fair trial at the hands of Sir William Thomson and Professor Jenkin' which Mr. Herring asked, which Mr. Scudamore admitted his claim to, and invited

* "Constitutional History of England," chap. xv.

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him to make costly preparations for, and which you also by your letter allow that he is entitled to."

I am afraid I am trespassing too much upon your space, but the question is really one of much national importance—Whether the Telegraph Department of the Post Office is or is not so conducted that it is unwise for an inventor to entrust original ideas to its officers? "J. L." says he "don't see any great crime in the Government reconsidering their permission to grant a fresh trial," and yet he asks to be informed whether my invention "has been exhibited, and with what verdict." In conclusion, therefore, permit me to answer this question by an extract from my article on "Recent Obstructions in Telegraphy:"—

"If any demonstration were needed of the hopelessness of expecting fair play for an outsider from the telegraph authorities, their conduct in reference to the recent Loan Exhibition of Scientific Apparatus at South Kensington would supply it. At that exhibition the Postmaster-General exhibited the instruments which I entrusted to the Post Office for the purpose of the proposed trial. But, although the instruments were exhibited, they were at first omitted from the catalogue and labelled incorrectly. When a second edition of the catalogue was being prepared, I applied to the director of the exhibition for permission to write or revise a description of them. Instead, however, of obtaining such permission, the director, Mr. Cunliffe Owen, replied, 'The General Post Office can alone be recognised as the exhibitor of the instruments, and the only description that can be accepted for the catalogue is that which has been furnished by it.' I then applied to the Postmaster-General, who answered by his secretary, that the 'labelling and description of the various instruments exhibited had been carried out under the supervision of the authorities of the exhibition, and that his Lordship must refer me to them as regards the labelling and description.' I again applied to the director of the exhibition, who answered that the description of the instruments had been furnished to him by the Postmaster-General.

"The next instrument to mine in the second edition of the catalogue, numbered 1,564 E, was described as printing the signs transversely. Now it cannot be doubted that this erroneous statement was made by the authority of the Post-office, and might be altered by the same authority. It was manifestly so described to produce the impression that the Post-office had another instrument which would do what mine did. But the authorities of the Post-office would not state this distinctly, because they would then be liable to be asked why, if they had got such an instrument already, they had spent money in trying mine. But, although this statement could not be made, it might be insinuated, and, when I challenged the covertly hostile paragraph, I was told that the responsibility for it rested with the officers of the exhibition, who, however, met this assertion of the Post-office with a distinct and positive denial."—I am, Sir, your obedient servant,

RICHARD HERRING.

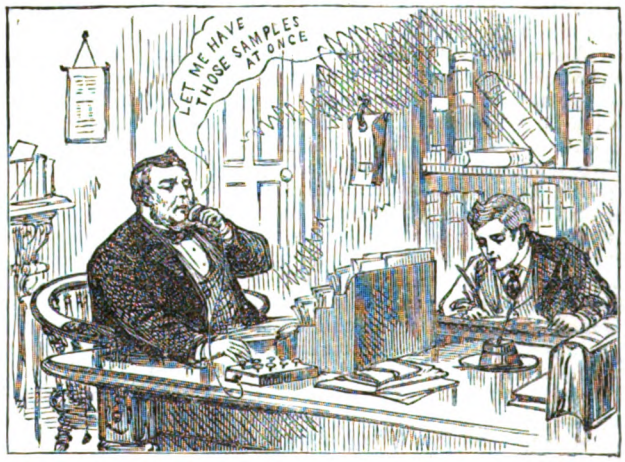
27, St. Mary's-road, Canonbury, December 10, 1878.

TELEPHONES.

The great excitement about the electric light has for a moment overshadowed that of the telephone; but those directly at work on the latter have not allowed their attention to be conducted into another channel. Constantly, yet quietly, improvement is being added to improvement, till there seems every possible chance of the telephone being adapted to the requirements of the house, and, in fact, that it will be made an indispensable adjunct to the fittings of every ordinary dwelling. Our purpose in this article is to notice the advances that have recently been made in this direction. It will be remembered that, on its first introduction, the great outcry against Bell's telephone was its price. The Telephone Company, we believe, have purchased the patent for this country, and hence have the sole right of manufacture and of sale. Besides its cost, there were many other difficulties to be overcome before it could be generally adopted. How was a listener to know when a speaker desired his attention? It was impossible that one could keep a telephone constantly at one's ear, and thus a signal of some kind became necessary, and several ingenious pieces of apparatus were devised for this purpose. The simplest and the best was the bell. Mr. M'Clure, the recent manager of the Telephone Company, in his desire to simplify the apparatus, was singularly happy in suggesting that the push of the bell should form part of the telephone. In the watch telephone, for example, a small knob on the side of the telephone serves to make contact between the battery and the bell; and, by a prearranged system, a vast amount of labour can be saved. Suppose you want to give directions to a servant, one stroke on the bell calls him to the telephone. If you want him at your elbow, two strokes tells him it is no use listening, but he must come at once. This, then, was one step in advance, but it was felt desirable to connect every room in the house with the servants' hall, or every room in the hotel with the central office, and, *vice versâ*, in large business houses, the manager's office with every other part of the premises. In the first case, dining room or drawing room, or bed room, or nursery communicated with the servants' hall. In the latter case, the principal or manager could give directions to whomsoever he wished and wheresoever on his premises he required. We shall see, further on, the means adopted to carry out these improvements. As to the cost, we are assured that a house can be fitted up with the telephone and bell combined at about the same expense as would be incurred in fitting it up with electric bells only. If this be the case, and we have every reason to believe that it is so, there can be no doubt as to the great future of the telephone. The sounds may be weak, but, if it is to be had, together with the bell, at the cost of the bell only, we shall not grumble at having to pay a little attention to what is said. Then, as to the improvements in the details of the telephone itself. At first, a good deal of trouble was given in the adjusting of the magnet, but now the magnet is fixed, and an ingenious arrangement made in the case of the hand telephone by which the vibrating diaphragm is easily and accurately adjusted, and in the case of the watch telephone the pole piece and coil are made adjustable, by which the vibrating diaphragm is easily and accurately adjusted. These little improvements are easy to talk about, but very seldom made without a large amount of thought and trouble. Instead of the diaphragm being placed on a sunk rim in the mouthpiece, this part of the telephone is made square. The diagrams herewith given are intended to indicate the household purposes to which the telephone may be put. For these seemingly ridiculous services we have now to ring a bell, and, when it is answered, to give commands; but with the telephone and bell combined the trouble of answering the bell will be avoided, and whatever we require can be brought to us at once.

Returning for a moment to the watch telephone hanging from the dining-room table, by one's bedside, or other convenient place, it was only necessary to have a telephonic indicator in the kitchen or servants' hall, arranged so that an ordinary domestic servant can put a telephone in the circuit indicated, and receive the instructions which he or she, without such means of communication, would only obtain by a journey to the room.

The two accompanying sketches show the manager of a business communicating with one of the foremen; the arrangement being that in which, by means of a commutator, the operator is able to call any person or to speak to any department in a large establishment. The other sketches, relative to a request for shaving water, illustrate the reverse arrangement, by which a number of persons can communicate with a central office. The indicator here is made for twelve rooms only, but the principle is as easily applied to large as to small establishments.



All the telephonic circuits are arranged to be open ones, so that the operator in the central office can alone close the telephonic circuit. Mr. M'Clure made this arrangement in order to prevent the possibility of the occupier of one room—or, on longer circuits, to prevent the occupier of one office being able to tap the communications that might be going on from any other office to the central station—being able to tap, so to speak, the communication with any other room. With a view of providing for the future arrangements of telephonic communication, this indicator is so arranged that, when used in large establishments or on long lines, that is from one part of a town or country to another, any two lines can be joined through the indicator, and thus communications can be held between any two rooms, or any two places, in the same way as to the central office.

We are glad to see that an attempt is to be made to make the

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telephone still better known practically with our young people. Christmas gifts of a costly character are not unknown, and many a parent and friend will think a gift far from expensive which consists of a pair of telephones with some twenty-five yards of necessary wire hidden away in a pretty "surprise" box. Besides

these innovations, Mr. M'Clure has been endeavouring to perfect an apparatus which can be used for military purposes, but this we hope shortly to mention at greater length.

[We are indebted to Mr. M'Clure for these diagrams.]

ON THE PRACTICAL APPLICATION OF ELECTRICITY TO LIGHTING PURPOSES.*

By JAMES N. SHOOLBRED, B.A., Mem. Inst. C.E.

(CONTINUED FROM PAGE 33.)

Northern of France Railway Goods-Station at La Chapelle, Paris.—This company, finding that the night work done in the goods sheds and in the yard outside was very inferior in amount to that done during the day (about 37 per cent. per head), and that, moreover, a considerable number of small articles were mislaid and lost during the night work, determined to try the electric light to improve matters.

A series of six single-light "Gramme" machines were provided, each of the size termed "A" (6,000 candles), and a portable engine of 15-horse power nominal. A special shed was erected to contain the electric machines and the engine. Several forms of lamp were tried, but that made by Serrin was ultimately preferred. Latterly, however, a modification of that lamp by Suisse has been used with great advantage, as it allows of twelve hours' consecutive burning, in place of only three-and-a-half with the original Serrin. The average length of the night work was found to be ten hours, with a maximum of fifteen hours. The first outlay (intended for five-light centres), consisted of six machines, six lamps, portable engine, shed, conducting cables, &c.; this, fixed complete, amounted 1,640*l*. The electric lights were placed one in a goods shed, the remainder in the open yard, so as to light up a row of turntables, where most of the night work took place. The shed is 230ft. long, and 75ft. wide, with a span roof 33ft. high at the ridge, and 16ft. at the eaves, and having a central skylight along each side for most of its length; the upper portion of the walls and the underside of the roof were whitened to aid in reflection. The electric light is hung near to the centre, in a simple lantern of ground glass, and at an elevation of 15 feet from the ground. The effect of this illumination was to increase the effectiveness of the night work by 30 per cent. The original, imperfect gas illumination had been carried on by means of 21 jets, burning 4¼ cubic feet each. The new illumination was as effective as if these had been augmented to from 50 to 55, causing an hourly consumption of 220 cubic feet of gas. The light in the shed was found to give a good working light for a distance from it of over 100 feet, while those outside were satisfactory within a radius of 200 feet.

The electric illumination commenced on January 15th, 1877, and has continued regularly ever since.

During this period a series of careful experiments was carried out by the officers of company. The results showed that on an average 2¼ actual horse power was required per light per hour, sometimes a little more, sometimes rather less; and that the square carbons, of ⅜ inch a side, were consumed at the rate of 4 inches per hour, or at a cost of 1½d., waste included.

* A Paper read at the Society of Arts, 4th December, 1878.

The nightly working expenses, with an average of four lights and during ten hours, were found to be—

	s.	d.
Motor power—2·5 horse power × 7·8 lbs. coal × 10 hours × 4 lamps	7	0
Carbons—4 lamps × 10 hours × 1½d. (nearly)	4	10
Oil 8d., wood 1½d., lighting engine shed, 2½d.	1	0
Engineman's wages	4	0
	16	10

This gives a price per light per hour of 5d., add to this 10 per cent. on first outlay of 1,640*l*. for interest and depreciation, 2¾d.; total cost per light per hour, 7¾d. (say 8d.). This, to the railway company, would represent the cost of 22 gas jets, while the electric light, in the shed, was considered to have satisfactorily replaced 52 jets, thus leaving an economy of 30 jets, or about 60 per cent. in favour of the electric light.

Iron Works of Messrs. T. and T. Powell, Rouen.—In the autumn of 1876, Messrs. Powell determined to illuminate a newly-made erecting shop with electric light. It is a building 125 ft. long by 45 ft. broad, with open roof 26 ft. high at the eaves, and 40 ft. at the ridge.

Two single-light Gramme machines, of the small or "M" size, with two Serrin lamps, conducting cables, &c., were provided, and fixed complete for 196*l*. The lamps were suspended under the centre of the shed, 60 ft. apart from each other, and at a height of 30ft. from the ground. No special motor was provided, the requisite power being taken from the engine which served to give motion to the tools, &c. A series of carefully taken indicator diagrams showed that, on an average, 2½ indicated h.p. was absorbed by each light, which was found to contain an intensity of 1,900 candles (measured horizontally). This illumination (costing actually 4d. per hour per light) would come out, if with an allowance for a special engine, and 12 per cent. for interest and depreciation, at a total expense of 2*s.* 10*d.* per hour; as against 7*s.* 7*d.*, for an equally effective illumination with gas, at 7*s.* 8*d.* per thousand cubic feet, the price in Rouen.

Messrs. Powell, after two years' experience of the working of the electric illumination, and finding it so much cheaper, more effective, and safer than gas would be in their erecting shed, have decided to extend it without delay to the rest of their works.

A very considerable number of applications of this class of single light electric machines, both of the Siemens and of the Gramme construction, exist in France and in this country, and serve for the illumination of industrial works differing very widely in character. The data, however, given in the above examples afford some test as to the capabilities and as to the working expenses of this class of machines.

(TO BE CONTINUED.)

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES Dec. 11.		BUSINESS DONE WEEK ENDING Dec. 11. Highest.	Lowest.
Anglo-American	58,	½	59½	57¾
Do. "B"	85,	½	86¾	85
Do. "A"	33,	½	35	32½
Brazilian	6¼,	¼	6 11-16	6¼
Cuba	8¼,	¼	—	—
Do. Ten per Cent. Preference	15¼,	¼	—	—
Direct Spanish	2,	¼	—	—
Do. Ten per Cent. Preference	9¼,	10¼	—	—
Direct United States	11¼,	12½	12½	11¾
Eastern	7¼,	¼	7 9-16	7 7-16
Do. Six per Cent. Debenture	103,	105	—	—
Do. Five per Cent. do.	100,	102	—	—
Do. Six per Cent. Preference	10¼,	¼	10¾	10½
Eastern Extension	6 15-16,	7 1-16	7 5-16	6 15-16
Do. Six per Cent. Debenture	104,	107	—	—
German Union	8,	¼	—	—
Globe Telegraph and Trust	4¼,	5	5 1-16	4¼
Do. Six per Cent. Preference	10¼,	⅜	10¾	10¼
Great Northern	7¼,	8	8¼	7⅞
Indo-European	19½,	20½	—	—
Mediterranean Extension	2¾,	3	2⅞	2¾
Do. Eight per Cent. Preference	8¾,	9¼	9	9
Reuter's	10,	11	—	—
Submarine	217,	222	220	220
Panama	1¾,	2	2	1¾
Do. 1st Preference	8,	¼	7¾	7¾
Western and Brazilian	2¼,	¾	2 9-16	2 9-16
West. Union Seven per Cent. 1st Mort.	114,	118	—	—
Do. Six per Cent. Sterling	100,	102	101	101

TRAFFIC RECEIPTS FOR NOVEMBER, 1878.

COMPANIES.	Nov. 1878.	Nov. 1877.	Incrse.	Decrse
Anglo-American Telegraph Company	£51,090	£47,890	—	£8,200
Brazilian Submarine Company	12,753	12,233	—	520
Cuba Submarine Company	2,600	2,859	—	259
Direct Spanish Telegraph Company	1,001	885	116	—
Direct United States Telegraph Company	17,030 estd.	12,920	4,110	—
Eastern Extension Telegraph Company	25,280	20,794	4,486	—
Eastern Telegraph Company	37,170	38,439	—	1,269
Great Northern Telegraph Company	16,587	17,670	—	1,083
Submarine Telegraph Company	9,549	9,817	—	268
Western and Brazilian Telegraph Company	—	11,226	—	—
West Coast of America Telegraph Company	2,200	1,800	400	—
West India Telegraph Company	4,676 estd.	4,294	382	—

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NOTES.

THE SUISSE LAMP.—In our note on p. 25 the resistance of the lamp and carbon should be ·3 ohms instead of 3 ohms.

PHOTOMETRIC VALUES OF THE ELECTRIC LIGHT.—It is stated that the photometric measurements made by the "Board of Works" give a much lower value to the electric light than has hitherto been assumed as correct.

THE BROWNING LAMP.—We understand that Messrs Gardner are about to introduce a lamp designed by John Browning. The carbons in this lamp are intended to be placed horizontally, although if required it can be adapted to any position.

ELECTRIC LIGHT APPLIED TO SHIPS.—The electric light is finding extended applications. At Bremen a ship, bearing this light at its prow, has been able to sail down the river at full speed in the night. The Imperial dockyards at Kiel are now illuminated on the Jablochkoff principle.

THE JERSEY CABLE.—The cable between the English shore and the Channel Islands has, after an interruption of some two or three weeks, been repaired, and communication re-established. The fault was found at a short distance from land, on the English side of the Channel.

THE EASTERN EXTENSION TELEGRAPH COMPANY.—The directors of this Company have declared an interim dividend for the quarter ending Sept. 30 last of 2*s.* 6*d.* per share, or at the rate of 5 per cent. per annum, free of income-tax, payable on Jan. 15. The books of the Company will be closed from the 7th to the 14th proximo inclusive.

THE FROSTERLEY LEAD MINING COMPANY (LIMITED).—The prospectus is issued of the Frosterley Lead Mining Company, capital 10,000*l.*, in shares of 1*l.* each. The mining property which the company is to purchase is situated in the county of Durham. The copy of a report by Mr. J. Henwood is annexed to the prospectus.

DID THE ANCIENTS KNOW THE DIRECTIVE POWER OF THE MAGNET?—The only thing that seems capable of being mistaken for some such knowledge is what Jamblichus tells us in his life of Pythagoras, "that Pythagoras took from Abaris, the Hyperborean, his golden dart without which it was impossible for him to find his road." Can any reader supply any other reference which seems to point to a knowledge of the peculiarities of the magnet?

ANOTHER ELECTRIC LIGHT.—Charles E. Buell, of New Haven, a telegrapher, well-known in New England for originality of ideas, has devised an electric light which admits of use in either a single or divided current, requires no adjustment, avoids the employment of platinum or carbon electrodes, and may be said to be without expense for material consumed, and the light can be of any colour known in pyrotechnics.—*Hartford Evening Post.*

MURDER OF AN ENGLISHMAN IN CRETE.—CANDIA (CRETE), DEC. 16.—The Eastern Telegraph Company's superintendent at this place, Mr. William Anderson, and a native *employé* were foully murdered outside the gates of the city on Saturday evening. Mr. Anderson was much respected and esteemed by all classes and creeds. He was a nephew of Sir James Anderson, the managing director of the company which he represented. Her Majesty's Consul, Mr. Sandwith, has proceeded from Canea to investigate the outrage.

L'ELETTRICISTA.—The success of our Italian contemporary has been so marked that it has been determined to issue it as a weekly, with the title, "La Natura," if the necessary support be forthcoming before the end of the year. It is almost needless for us to add that this publication has contained, from time to time, some very able and interesting electrical papers, and, although under its new title it will extend its sphere and treat of science generally, it will still devote special attention to electrical matters.

THE POWER TRANSMITTED BY WIRES.—At the electrotype works of the Société Val D'Osne in Paris, M. Cadias, the engineer, has for the last two years employed two Gramme machines to transmit the superfluous power of an engine from one part of the works to another. The connecting wire is about 5mm. diameter, and from 150 to 200 yards long. The power transmitted is said to be about 60 per cent. of that employed. The second machine drives another dynamo-electric machine, which furnishes the current to electroplate large surfaces, some of the articles electroplated weighing several tons.

PATENTS BY CABLE.—Seven patents were granted in England alone for electric light between Oct. 29 and Nov. 4. About one-tenth of all the patents now taken out in Great Britain are for electric lights. Mr. Edison patents all the discoveries made in his experiments, both in the United States and in England. Sometimes he makes quick work of it. Last week he made a discovery at 4 o'clock in the afternoon. He got a wire from Menlo Park to Plainfield, where his solicitor lives, and brought him into the telegraph office at that place. Mr. Edison wired him the discovery. He drew up the specifications on the spot, and about 9 o'clock that night cabled an application for a patent to London. Before people were out of bed next morning Mr. Edison received information that his application had been filed in the English Patent Office. The application was filed at noon, and he received information about 7 in the morning, five hours before the filing. The difference between London and New York time explains the matter.—*Operator.*

AN ELECTRIC METER.—The following letter has been published relating to a meter to measure the electric current:—"On the 4th inst. it was announced by telegraph from New York that Mr. Edison had 'perfected a machine measuring the current used in the electric light.' It may be of some interest to your readers to know that Mr. St. George Lane Fox, about a month before that date, completed his invention of an electric meter, and obtained protection for his invention by provisional registration in the Patent Office on the 14th of November last. Having for many years given much attention to the usual modes of measuring gas and water, I venture to express my opinion that inventors of improvements in the practical application of the electric light

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for domestic and other purposes may rest assured that no difficulty is likely to impede the adoption of electric lighting in regard to the means of measuring its supply. Without knowing anything of Mr. Edison's invention, I believe Mr. Lane Fox's electric meter will prove simple, efficient, and inexpensive.—I am, yours obediently, DAVID CHADWICK, 2, Moorgate-street, E.C., Dec. 10."

POST OFFICE TELEGRAPHS.—The report of the Postmaster-General for the financial year ended 31st March, 1878, has just been published. From that portion of it relating to the telegraphs, we learn that the increase in the number of public messages was less than usual, amounting to 445,640—a comparatively small increase, attributable to the continued depression in trade. On the other hand, owing to political events of unusual interest, there was an increase of 25 per cent. in the amount of press matter, upwards of 250 millions of words having been transmitted in the course of the year for newspapers, clubs, exchanges, and news rooms. Twenty-five additional post-offices were opened for telegraph business, making a total of 3,756 offices, besides 1,555 railway stations which act as public telegraph offices. The Postmaster-General, while calling attention to the errors in telegrams occasioned by the senders' own indistinct writing, and recommending greater care on the part of the public, explains how easily serious errors may unavoidably occur from very slight derangement of the signals. For example, the displacement of a dot caused the news that Mary was "bad" to be transcribed as the sad intelligence that she was "dead." In another case a pleasure party was announced as having arrived all "tight," when, in fact, it had reported itself "all right." From returns given in the appendix we learn that the total number of telegrams forwarded from offices in the United Kingdom was 22,171,783. Of this number nearly seven millions originated in London, being more than four times the number for all Ireland, and about three times the traffic of Scotland. The revenue from private wires was 58,329*l.* The total gross telegraph revenue for the year was 1,333,542*l.*; the working expenses 1,164,131*l.*, leaving a net revenue of 169,411*l.*

MERCUROUS SULPHATE.—This, which is also called the protosulphate of mercury, is the salt with which the Marié-Davy battery and the standard cell of Mr. Latimer Clark, giving the E.M.F. of 1·457 volt, should properly be mounted. The salt in question has the formula $Hg_2 SO_4$. Unfortunately, the mercuric sulphate, or persulphate of mercury ($Hg SO_4$), being a cheaper salt and one more readily prepared, is very generally substituted for it. We say unfortunately, because, whilst the protosalt is admirably adapted for use as a depolarising agent, the persalt is decidedly unsuitable for the purpose. The former is not decomposed by water, and is but very slightly soluble, scarcely more than sufficiently so to keep the zinc duly amalgamated; whilst the latter is decomposed by contact with water into a yellow insoluble basic salt, and a very soluble acid salt, which rapidly attacks the zinc element. One of Clark's standards, which we recently examined, was rendered quite useless through its being charged with mercuric sulphate, the fluid being so acid as to react upon the zinc with production of hydrogen, the pressure of which had forced all the mercury through the small connection-tube leading from the bottom of the glass containing-vessel. Mercurous sulphate may be produced by boiling *excess of* mercury with sulphuric acid—that is to say, by boiling until all the acid is consumed, and a white powder remains *together with undissolved mercury*, which, of course, must be separated from the salt. Or it may be obtained by acting upon mercury with cold dilute nitric acid, and adding from time to time to the solution sufficient sulphuric acid to precipitate as mercurous sulphate the greater part of the mercury present in the form of mercurous nitrate. Nitric acid is thus liberated, which reacts upon a further portion of mercury. In the latter case, especially, the mercurous salt should be well washed if it be intended for the production of a standard of E.M.F., or for any purpose involving similar delicacy and care.

THE ELECTRIC LIGHT ON THE THAMES EMBANKMENT.—At length residents in the metropolis are enabled to judge of the value of the electric light as compared with gas for street lighting. We have more than once visited the scene of operations, and will give a general idea of the arrangements. The engine and machinery for generating the electric current are placed in a wooden house to the west of the Charing-cross railway bridge, and the conducting wires are led under the roadway to the subway and thence to the lamps on the parapet. The general arrangement of the machinery has been entrusted to Messrs. Ransomes, Sims, and Head, of Ipswich (who have lent the engine and supplied the shafting, &c.). The engine is an excellent example of workmanship. It is of 20-horse power nominal, and has two cylinders, each 10in. in diameter, with a 13in. stroke, and making 140 revolutions per minute. It is supplied with steam by a locomotive boiler, with about 360ft. of heating surface. The engine—which is of the semi-portable type—is furnished with an automatic expansion governor, similar to that described by us in our last issue, which regulates the speed of the engine to the greatest nicety, a matter of great importance in driving machinery for electric lighting. The engine indicates from 60 to 70 horse power, and is sufficiently powerful to drive two dynamo-electric machines capable of lighting 40 Jablochkoff candles. By means of an intermediate shaft and pullies two Gramme machines are driven. One of the direct-current type machines is used to supply the current to the electromagnets of a second alternating current machine, the current from which is led into four circuits containing five lamps each. These lamps are placed on the river side of the Embankment. Altogether, there are nineteen lamps within a distance of 1,170 yards. The furthest lamp on the Waterloo side is situated about 470 yards from the apparatus, while the furthest lamp on the Westminster Bridge side is 700 yards from the machinery. The average distance between two lamps is about 45 yards, but some of the lamps are greater distances apart, as, for instance, the one on the Waterloo Bridge side nearest the machine and the one under the Charing-cross Bridge, which are 115 yards apart, and the distance from the latter lamp to the first one on the Westminster Bridge is 120 yards. One lamp is placed within the engine shed for experimental purposes. These experiments have already commenced, but, as yet, too little time has elapsed for many results to have been obtained. We were anxious to know the exact horse-power used by the machines, but this, as yet, has not been ascertained. Diagrams, however, will shortly be taken, and then for this experiment, at any rate, the exact power required will be known. We are sorry that the Board of Works restricted itself to the Jablochkoff bougie, because we quite agree with Mr. Shoolbred in his statement (*v.* paper read at Society of Arts) that this candle is obsolete. The expense is far too great, according to all accounts, to allow of its economical use as compared with gas.

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THE MERITENS DYNAMO-ELECTRIC MACHINE.*

Of all the electromotors adapted for the production of the electric light that which at the present moment gives the most surprising results is certainly the machine recently constructed by M. de Méritens.

Since the description† we gave of it, this powerful electro-generator has engaged a large amount of interest and curiosity in the worlds of science and industry. Every Wednesday evening a numerous society of French and foreign *savans*, engineers, *constructeurs*, and persons interested in the progress of electricity, throng the workshops of M. de Méritens. This week we attended one of these interesting experiments. Fifteen electric globes lit up the place, giving the effect of broad daylight.

Everyone was pressing round the new generator, without being able to understand its mode of action. Under the impossibility of answering all the questions addressed to him, M. de Méritens adopted the plan of holding a conference on the subject of electro-generating machines and electric lamps. This subject was treated in so clear and instructive a manner, and was such a success with the audience, that we would fain reproduce for our readers the principal passages of this interesting scientific chat:—

"The electric light, at the present moment, has become a need, a necessity. It has entered into our habits and customs. This century, which will remain the greatest, has seen the birth and the growth of the steam engine and of electricity. Its close will witness the association of these two powerful agents, which become united in the new applications of electricity to the production of light. The time has come for practical minds to study the means at our disposal for producing the electric current, and the apparatus which vie with each other in utilising it.

"Two classes of electro-generators are in presence, the *magneto* and the *dynamo*-electric machines.

"The former derive their electricity from permanent natural magnets, and the second from artificial magnets, that is to say, from electro-magnets. The magnets of one kind are stable, lose nothing, and even improve by use; those of the other kind have to be excited and maintained by an expenditure of dynamic energy.

"From an industrial and economic point of view, there is consequently no question as to which should be preferred. But the advantages of magneto-electric over dynamo-electric machines are not confined to this direction. A permanent magnet does not change in value, in magnetic power, according to the velocity of the receiver of electricity which passes in front of its poles. It is, and it remains, analogous to a generator of steam under a constant pressure. This is not the case with an electro-magnet influenced by a dynamo-electric machine. Here the magnetic power is essentially variable. If there be any change, even an imperceptible one, in the velocity of the machine, the artificial magnet obtains very different quantities of energy from one mathematical moment to another. The simple slipping of a driving belt suffices to produce this effect. From this cause result incessant variations in the current produced and collected, variations which effect continual changes in the intensity of the light obtained. In order to guard against this serious drawback, the natural course is to obtain from the machine its maximum effect, *i.e.* to force it to produce its electricity with a maximum of tension. If this were not done the light would be insufferable. But then another objection comes into play, one of which we have daily proof; the alternating current, the only one used for public lighting—this current which changes its direction as often as two hundred or more times per second—forms condensers from layer to layer in the coils through which it circulates. Utilised at a high tension, it soon impairs the insulating materials, and often, after working for a very short time, the machine becomes unserviceable, apparently from no assignable cause.

"The case is analogous to that of a Rhumkorff coil which has been worked with too powerful a battery. This elementary observation has struck every *savant* to whom it has been pointed out.

"Thus, practical convenience and economy urge the adoption of the *magneto-electric* machine.

"The first and the most remarkable amongst this class is the *Alliance* machine. This has furnished the illumination of the lighthouses on the coasts of France and England for over twenty years, without any alteration. In fact, at the period when it was constructed, induction was yet in its infancy and had received no applications."

M. de Méritens has succeeded in combining, in the ring of his machine, all the inductions known in physics. He has obtained the extraordinary result that one of the old *Alliance* machines, which formerly gave *three* Jablochkoff lights, gave *twelve* such lights, after its transformation, in accordance with the Méritens' system, during the *soirée* which we attended; and that, with a slight increase of speed, it could, as was shown to us, work *sixteen* of the *bougies*. One-third of a horse power per *bougie* is used, instead of one-and-a-quarter or one-and-a-half horse power, which is requisite with dynamo-electric machines.

These few details having been given in relation to generators of electricity, the question of *dividing the electric current*, which M. de Méritens termed a trivial one, was next referred to.

"The division of the current, which all the newspapers have spoken of for some time past, was known to Volta, to the Abbé Nollet, to the first who constructed a voltaic battery, and to the first constructor of a mechanical generator of electricity. Electricity, like water in a reservoir, or gas in a gasometer, escapes through and is divided by all the taps that may be opened for it. It is the greater or less degree of efficacy of the orifice for the water, of the burner for the gas, of the regulator for the lamp, or of the *bougie* for electricity, which renders the divisibility practicable. It is neither the reservoir, nor the gasometer, nor the generator.

"In the numerous articles which have been written on the supposed discovery of Mr. Edison in relation to the divisibility of the light, the name of the electro-generator which he has selected—the Wallace machine, one of the least perfect of those which have been constructed—was frequently mentioned. But the regulator, the lamp, or the bougie, which he may have adopted was never called into question.

"In all these pieces of apparrtus it is absolutely necessary to employ some substance which is either combustible, fusible, or volatilisable.

"No substance in nature can escape from some one of these conditions in the voltaic arc. Therefore, he, like others, must have some apparatus—regulator, lamp, or *bougie*—which regulates combustion or arrests fusion, or which controls volatilisation. It is a circle in which one has to turn; one can only choose between them. We are acquainted with all the regulators which have latterly appeared. Some of them, like that of Rapieff, are very ingenious; others, like that of Werdermann, imitated from the Regnier lamp, are very efficacious for the division of the current. But where is the practical engineer who would undertake to light up a street, a *boulevard*, or a large public square with one of these instruments? Let there be the least oxidation in a spring continually exposed to moisture, the smallest foreign body interposed between the points of contact of the carbon, and human interference becomes indispensable if the light is to continue. In a workshop, in a private apartment, the remedy is possible, and even easy. But the word remedy indicates that there is something to be cured.

"The ingenious discovery of M. Jablochkoff seems to us to be the best and the most practical solution of the question of public lighting by means of electricity. Here we have the sanction of experience. No wheelwork, no spring, no moveable parts. Let one bougie be burnt out, or the three, four or five *bougies* in a circuit be burnt out; and, by touching a key, or a commutator, such bougies are instantly lighted. Objection has been taken to the cost of the light. But, like all things which are of the first necessity, this light has diminished in cost to a wonderful extent since its first appearance, hardly a year ago. The *Société Générale d'Electricité* were paying a year ago ten times as much as they now pay for the carbon of the bougies.

"At the present moment it can already enter into advantageous competition with gas, in regard to the price of equal quantities of light. With the machines of M. de Méritens, which economise 75 per cent. of the force employed, it will be impossible for gas to compete in the illumination of large surfaces.

"Thus, we shall see the principal thoroughfares illuminated like the *Avenue de l'Opéra*. We shall see all the large drapery establishments imitate that of the Louvre, which has augmented by several hours its periods of sale, diminished by 25,000 to 30,000 francs per annum its insurance premiums, and preserved free from damage those light-coloured fabrics which are impaired by the sulphurous action of gas.

"The clerk after his work at the desk, the artisan after his day at the workshop, can in the evening make the purchases necessary for their families. People will live eighteen months in one year! I trust," said M. de Méritens, in conclusion, "that all here will agree with me when I assert that the electric light has now won its rights of citizenship amongst us."

From every side applause greeted the speaker, and an illustrious English savant, shaking M. de Méritens by the hand, assured him that his magneto-machine was not one amongst the light-producing machines in existence, but was *the* light-producing machine.

One undoubted defect of magneto-electric machines, which appears to be denied by M. de Méritens, is the gradual loss of magnetism by the permanent magnets.

* Translated from *l'Electricité*. † *Vide* p. 27, Vol. II.

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SIEMENS BROTHERS' DYNAMO-ELECTRIC LIGHT APPARATUS.

[CONCLUDED FROM PAGE 40.]

Conducting or Leading Wires.

The leading wires are usually of copper of high electrical conductivity. They must be insulated from one another the whole of their length, and not placed too close together. As their resistance affects the intensity of the light very much, the section must be carefully proportioned to the distance of the lamp from the machine.

The best practical result is obtained when their resistance, together with that of the lamp, is equal to the total internal resistance of the dynamo machine. Wires of various sizes are, therefore, required. The following is one type adapted to a distance of 120 yards between the machine and lamp :—

It consists of a strand of 19 copper wires, No. 16 B.W.G., covered with layers of cotton tape and india-rubber.

Decrease in strength of the current caused by a leading wire of too high resistance can be overcome by a higher velocity, which is obtained only by increased motive power, but if the wire is much too small it will become heated. The proper remedy is to increase the sectional area of the leading wire.

Bright sparks should never be allowed to appear at the commutator and brushes, as sparks result from a rapid burning of the metallic parts. They can easily be avoided by properly inclining the two arms which carry the brushes.

The position of the brushes yielding the least spark at the commutator is that giving the highest intensity of light in the electric arc.

The commutator should, while in motion, be freely oiled to prevent the brushes wearing away too rapidly. The sticky oil should, from time to time, be removed by washing with paraffin oil or benzoline.

Wear and Tear.

The chances of stoppage so common to the old forms of electric light apparatus have in this form been reduced to a minimum, and now do not exceed those that arise with machines generally. The Trinity House Report states that the Siemens machine worked well for a month without any necessity for stopping. The brushes are the only parts which wear away, and they are very easily replaced.

Some experiments were made at Fort Monckton on behalf of the British Government in July, 1875, with the Siemens, the Gramme, and the Wilde machines. The results are given in the minutes of the Institution of Civil Engineers for 1878, and they show the vast superiority of the Siemens machine over other machines of that time. Since that, during a series of experiments made at the South Foreland Lighthouse for the purpose of selecting the best electric apparatus for the Lizard Lighthouse, the Siemens machine was proved to be the cheapest, lightest, smallest, and the most powerful. (See Trinity House Report, in which a very full account is given.) Six of these machines are now erected in pairs at the Lizard, and they give a very excellent light. They are so arranged that they can be worked either single during fine weather or in pairs during thick weather.

The reason for erecting them in pairs and connecting them in what is called parallel circuit (or parallel arc, or for "quantity,") is because it has been found that when they are so arranged the intensity of the electric light produced exceeds by some twenty per cent. the intensity of the sum of the two when worked separately. Thus the two medium machines, giving respectively a candle power of 4,446 and 6,563 when worked separately (total 11,009) gave when coupled up in parallel circuit a light equivalent to 13,179 candles; just as in telegraphy it has been found that the rate of sending can be increased from 20 to 25 per cent. when the apparatus is coupled up in parallel arc. For this reason it is usual to employ two machines of medium size, instead oof one machine of large size. The intense light so produced is also much more uniform than that from one large machine.

Automatic Electric Lamp.

Automatic electric lamps have been constructed with spring clockwork to cause the carbons to approach one another to a certain point, when, by means of an electro-magnet, the clockwork is checked, and the carbon points are allowed to burn away to such a distance that, by the decrease of current, the clockwork is released and the carbons caused to approach again. With such lamps the clockwork has been a source of trouble, and it is liable to get out of order.

The lamp to be here described is actuated without clockwork; it also automatically separates the carbons after they have approached too closely, or touch each other; and, by this combined action of approaching and separating, the carbon points are kept at a proper distance apart, and a steady light is obtained.

The working parts are represented in the diagram Fig. 6, and Fig. 8 represents the largest size lamp, such as is employed for lighthouse illumination. Two smaller sizes of lamp, adapted for general purposes, are also manufactured.

E (Fig. 6) is the horse-shoe magnet with the armature, A, placed a short distance in front of its poles. A regulating screw *b* with the spiral spring *f* is attached to the lever A', forcing it against the stop *d*, and withdrawing the armature from the poles of the electro-magnet. When a current traverses the coils of the latter of sufficient strength to attract the armature and overcome the tension of the spring *f*, contact is made at *c*, which diverts the current from those coils. The consequent release of the armature breaks contact at *c*, the armature is again

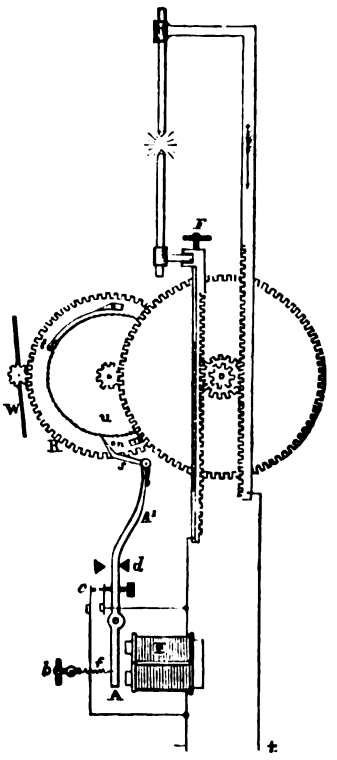

Fig. 6.

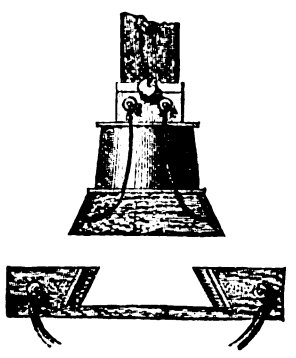

Fig. 7.

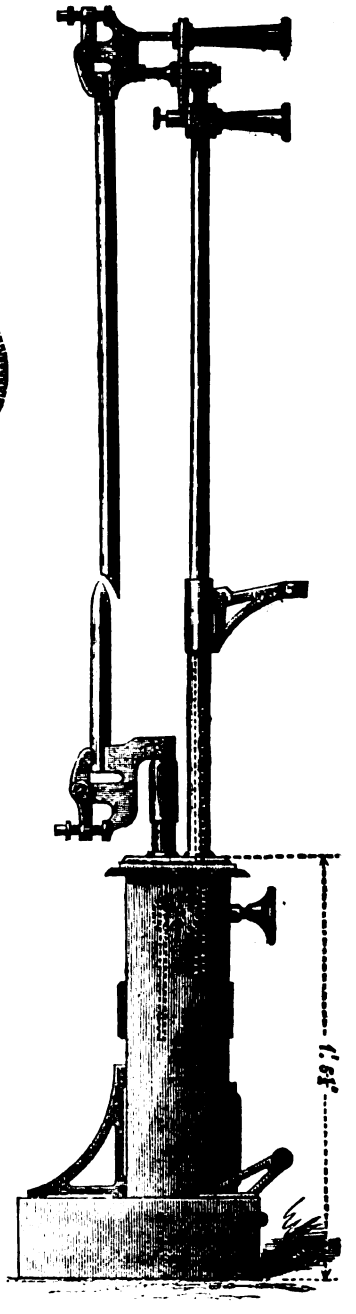

Fig. 8.

attracted, and this action is repeated, producing a vibrating motion of the lever and armature, which continues as long as there is sufficient current to overcome the tension of the spring.

The spring-pawl *s* at the upper end of the lever A', and oscillating with it, actuates a ratchet-wheel *u*, which is in gear with a train of wheels and the carbon-holders; it thus opposes their tendency to approach by pushing them apart, tooth by tooth, until the current is so much weakened by the increased length of electric arc that the armature and lever cease to oscillate enough to move the teeth of the ratchet-wheel, and it rests the stop *d*.

While in this position the spring-pawl is released from the ratchet-wheel, and the preponderating weight of the upper carbon-holder causes the carbon-points to approach again. In-

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crease of current follows decrease of resistance, the armature again oscillates, and this cycle of action is continuously repeated.

When in action the movements of the carbons are scarcely perceptible, but when, by any external cause, the carbons are separated so as to extinguish the light, they immediately run together until they touch, when they ignite and separate to a proper working distance by means of the electro-magnet above described.

The only operation requiring attention in the use of this lamp is the adjustment of the tension of the spring *f*. When this tension is once regulated to the current at disposal, the lamp will continue to give a steady light as long as the current remains uniform.

The relative rate of consumption of the two carbon points differs. The positive carbon burns away rather more than twice as quickly as the negative carbon.

The duration of the light depends mainly on the lengths and sizes of the carbons. The large lamp will burn for ten hours, while the smaller ones burn from three to four hours.

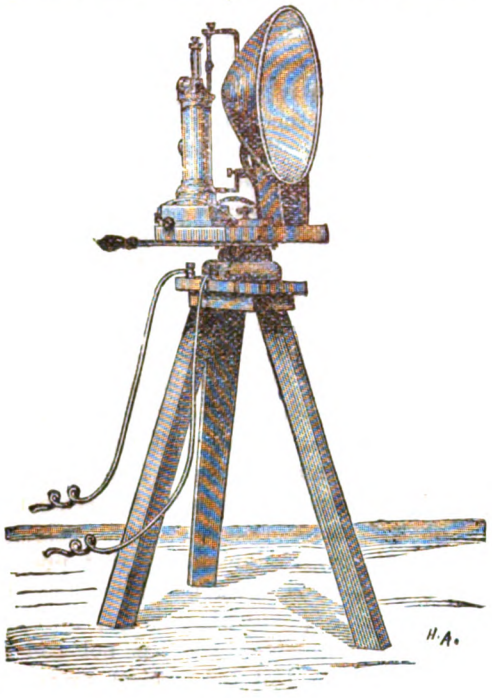

Fig. 9.

Provision is made in this lamp that the rack which supports the negative carbon may be made to gear either into the teeth of the same pinion as that of the positive carbon, or into one of about half the size. By these means the light, when once focussed in a reflector, will remain in focus as long as the carbons last, whether permanent or reversed currents are employed.

Besides its twofold application, the lamp is very compact, is simple in construction, and therefore not likely to get out of order, and it is capable of being regulated with great precision.

There is no spring to be wound up. The contact need not be cleaned, as the sparks are scarcely perceptible.

By removing two screws in the outside casing, all the chief working parts can be easily removed and inspected.

Fig. 8 shows the kind employed in the holophotes of lighthouses. It is made high and narrow, so that it can be inserted through a narrow slit in the holophote.

The carbons supplied with the Siemens Patent Lamp are coated with a thin film of copper. This enhances the cost somewhat, but it greatly improves the result, as the carbons burn longer and do not split when so coated.

By coating them the resistance is diminished, except at the points, so that all the heat is concentrated in the electric arc, and a brighter light is the result.

When two dynamo machines are coupled together to give a very powerful current, the sizes up to 20 mm. diam. are required.

The consumption varies a little, but the average is from 3 to 4 inches per hour.

To facilitate their renewal when burnt short, a spare lamp is sometimes used, which is kept supplied with fresh carbons. The lamp in that case has a small wedge-shaped contact-slide attached to its bottom (see fig. 7), so that it can be inserted quickly into a corresponding groove prepared to receive it. The process thus takes only a few seconds instead of as many minutes.

In the cable shops at Siemens Brothers' telegraph works near Woolwich, where the electric light has for the past two years taken the place of gas, and has been thoroughly tested, the economy has been proved, with the smallest and therefore least economical machine, to be as 2 to 1 in favour of electricity, taking it under most unfavourable circumstances, as regards cost of coal, and with interest on first cost at 15 per cent.

The advantage would, however, be much greater in favour of electricity if the light intensities were compared, for in the above case the electric light is three times as powerful as the gas formerly used. The ratio thus becomes 6 to 1 against gas lighting.

Two kinds of concentrating apparatus are supplied in combination with the automatic lamp, both of which are capable of giving a powerful parallel beam which will reach to an enormous distance, and are well adapted for naval, military, and other purposes. The one kind consists of a parabolic reflector of stout metal, its concave surface being silvered and burnished. The apparatus is mounted with a ball-and-socket joint upon a wooden stand, as shown in fig. 9.

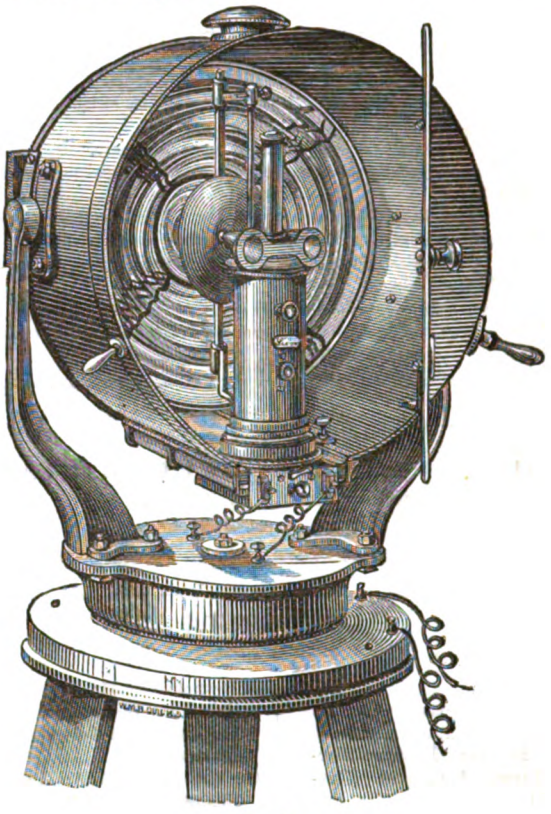

Fig. 10.

The other kind is the Fresnel Catadioptric lens or Holophote (see fig. 10) which may be substituted for the reflector, and gives a more powerful beam than one given by reflection. The lens is surrounded by a metal case or lantern, in which is placed the electric lamp upon a slide for focussing. Behind the carbon-points a hemispherical reflector is placed to catch all the back rays and reflect them back through the lamp focus. The entire lantern is capable of revolving on horizontal rollers, and swings upon pivots. Two handles are placed at the back to manipulate it.

As the electric arc is much too bright to be looked into with the naked eye, both concentrating apparatus are supplied with a lens, called a focus or flame observer, by means of which an image of the burning carbons is thrown upon small screens at the back, so that the lamp can be easily adjusted without fatigue to the eye. The focus observer is shown on the lamp in the Holophote, fig. 10.

MR. HERRING'S GRIEVANCE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As Mr. Herring has mistaken the remonstance which I made in the interests of your readers for one made in the interests of the Post Office, I hasten to undeceive him. He is simply wasting his strength if he thinks to reach the "official mind" either in me or through me. I congratulate him on the publication of the designs and description of his instrument. I have no concern or interest in anything else connected with it. J. L.

17th December, 1878.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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MR. HERRING HAS AN ANSWER.

Here is a case of which our readers are tired, the Post Office officials are tired, Mr. Herring is tired, and we are more than tired, yet, perforce, we are compelled to refer to it again. It has been our misfortune to have found it necessary, in one or two instances, to criticise adversely the actions of the Postal Telegraph authorities. We desire only to be just, and, however painful it may be to harp upon one string, it is sometimes necessary, and hence the duty must be performed.

> Cælo tonantem credidimus Jovem
> Regnare;

but as yet we are unable to say who wields authority in the Postal Telegraph Department. In August, Mr. W. H. Preece read a paper before the British Association at Dublin, which was ostensibly prepared in answer to the critics who had "intimated that the monopoly in telegraphy possessed by the State has checked improvement." Mr. Preece has a fair share of courage, and does not hesitate to speak in good set terms. The members of the British Association did not pass the paper without severe criticism. The *Society of Arts Journal* of August 23 contained Mr. Preece's paper; and on the following week, in the same publication, appeared two criticisms, one from the pen of Mr. R. Herring, the other signed "A Telegraph Engineer." We also printed Mr. Preece's paper, and reprinted the criticism from the *Society of Arts Journal*. The papers were taken from our pages by the *Journal of the Telegraph*, an American contemporary, and Mr. Preece has favoured that publication with an answer. *En passant*, we might point out the peculiarity of answering English criticism in an American paper. We should, in our ignorance, have thought that the proper place for Mr. Preece's letter was in the pages of the *Society of Arts Journal*. Perhaps, the editor thought it without the province of that journal to allow "telegraphic controversy" to block its columns. What will he say when he finds the observations which were printed by him designated as "the hairbrained chatter of anonymous frivolity?" Probably, however, Mr. Preece had in his thoughts, when writing the above expression, not only the *Society of Arts Journal*, but the dozen or so other papers which contain what the various writers thought were refutations of his statements. We have hitherto refrained from expressing any decided opinion upon the question of monopoly retarding invention, but we will now say, clearly and distinctly, that we do think monopoly has that effect. Mr. Preece gives us his opinion that the Government has no monopoly of the telegraphs in England, and, speaking strictly, he is correct, but the general opinion is that practically the telegraph system is a Government monopoly. He says: "Can any inventor be produced — except, of course, Mr. Herring, who is irrepressible—who has not had fair play from the Department! Did red-tapeism prevent or even retard the trial and adoption of the duplex and the quadruplex? Are there any lines in the world which convey more messages or work faster than ours? Are we behind any administration in technical efficiency or scientific experience?" It is easy thus to heap up questions in a foreign paper. Why does not Mr. Preece ask them in *The Times* or in the *Journal of the Society of Arts?* We think it sufficient to deal with one complaint at a time. Mr. Herring has made a specific charge, and the truth of that charge is not denied.

We are not called upon to determine whether the instrument of this inventor is better or worse than other instruments in use. That is the duty of those gentlemen selected by the officials in conjunction with the referees selected by Mr. Herring. The position seems to us quite clear. It has been acknowledged that the trials already made were insufficient, and further trials were promised before a final decision was given. According to Mr. Herring, these promised further trials have never been made, nor can he get any indication as to the time when they will be made, or any real answer to communications made by him on the subject to the authorities. We are seeking for causes to account for effects. Either our inventive genius is dying out or it is being smothered. We prefer to think the latter, and to believe that England is quite capable of giving us duplex and quadruplex instruments or systems, or improved dynamo-electric machines, or type-writing or printing instruments, but, as a matter of fact, England has not done so, whilst other nationalities have.

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Where can we point to our Bells, Baudots, Cours, Edisons, Hughes, Schæfflers, Pacinottis, Grammes, Meritens, Grays, &c. It is splitting hairs to say such men as Bell or Hughes must be claimed for England. Their work was elaborated in America after a long residence in that country, and probably had they been content to dwell in England neither the telephone of Bell nor the printing machine of Hughes would have seen the light.

Our American contemporary, in commenting upon the papers above referred to, makes the following statements:—

"What Mr. Preece says in reference to the quadruplex is liable to convey an erroneous impression to the minds of those not conversant with the facts. The quadruplex was first put in practical use on the Western Union lines in the summer of 1874, instead of 1876, and has been in constant operation ever since. The inventions suggested by Bosscha, Stark, and Heaviside, as well as the one patented by Stearns, are essentially different from the one which Mr. Preece tells us is working successfully in America and in England, and neither of them have been put in practical operation anywhere.

"The 'new line' in insulation which has been struck out by Johnson and Phillips is but a re-invention of an old American plan, precisely the same thing having been patented in the United States on November 26, 1867, by W. E. Simonds, of Hartford, Conn., and, if we mistake not, an illustrated description of the invention was published soon afterwards in the *Scientific American*.

"The table of patents taken out in England for improvements in telegraphy in the eight years since the telegraphs were taken over by the Post Office, it is true, show a small increase in the number of such patents over the preceding eight years. As stated in the above communication, foreign telegraphic inventions if of any importance are almost invariably patented in England, while but few foreign telegraphic inventions are patented in the United States. If the number of American and other foreign inventions included in Mr. Preece's table were deducted from the total, there is no doubt but that the showing would be much less favourable to British inventors. Not having the data at hand to show the relative number of native and foreign patents, the proportion of each cannot be definitely stated."

A very practical answer has of late been given to the question of England's inventive power in electrical matters. The agitation on electric lighting has called up a latent force, and, although many of the patents are undoubtedly useless, some of them will be found to be far in advance of anything that has gone before. Everybody believes that there is an opening for any good invention relating to the electric light, and inventions are poured forth. Now, with regard to telegraphy, we have either perfected our apparatus, or we have not; there is either room for invention, or there is not. If the department thinks there is room, and will take ordinary means to impress the fact upon the public mind, we shall soon have to recognise that applied electrical science has not fled from England. We do not believe that there is any nation that can show a stronger array of electrical talent than England; but those who can invent are beginning to understand that invention is one thing and the necessaries of life another. Once prove that there is a certain and not long deferred hope of fair remuneration for improvements in telegraphic or any other apparatus, and the improvements will be forthcoming. It is the fear of subjecting themselves to the treatment which has characterised the dealings of the department with Mr. Herring that frightens the inventors of England.

THE ELECTRIC LIGHT AND THE PUBLIC.

We have commented from time to time upon the scientific bearings of the Electric Light. Its recent exhibition at the Society of Arts enables us now to speak of it in relation to the general public. That long-suffering entity rushed headlong into the lecture hall, filling every crevice of it long before the advertised hour of meeting. For months past startling revelations have been foreshadowed in the newspapers, and nobody has come forward to tone them down, or to explain. Brilliant and, indeed, beautiful examples of electric lamps were to be seen in various parts of London, and the public gazed upon them with admiring wonder, but knew not whether to regard them as costly advertisements or as a heaven-sent economy. These perplexities hurried to the first promise of a solution—an earnest, eager crowd impatient for information. Its purpose was evidenced in the loud cries for "experiments," for "lamps," rather than listen to irrelevant histories; and its temper was typified in the militant umbrella, which gave a flourishing emphasis to questions that would no longer be put off. That umbrella worked wonders. It had come there to have a plain answer—*and it got it*. On the whole, therefore, we are disposed to consider the gathering as pre-eminently successful, although, on the one hand, enthusiasts for electricity were dissatisfied, and, on the other, the partisans of gas were unduly elated. There was no competitive exhibition of the kind promised—doubtless, without the least authority—by the daily Press; but such systems as were shown exemplified with sufficient practical clearness all the demerits and, perhaps, most of the merits of the new light. Moreover, encouraged by occasional shortcomings of the lights, and incessant importunities of the audience, there was an amount of plain speaking on the part of those whose utterances carried weight which was as refreshing as it was novel.

It was no fault of Mr. Shoolbred's if the audience came there with a wrong impression. It soon became evident that what the lecturer was prepared to give was not at all what those on the benches had come to receive. He had no cause to regret the result, however. Historic data and financial statistics had their value for advocates on both sides; but there was an unusual assemblage of impartial hearers whose sole concern was to seize—as they did seize—the salient points touching cost, power, and adaptability. The dimensions of a Paris railway station, the illuminating power of so many thousand candles, were not easily realized; but everybody could understand the significance of the Municipality declining to renew its contract for Jablochkoff lighting, the cost being twice as much as (Paris) gas. The doom of the unpronounceable candle was struck forthwith. A fate almost as summary awaited the Lontin light when it became known—thanks to the irrepressible umbrella—that the keyboard, suggesting as many subdivisions as there were keys, really represented nothing of the kind. This was hard lines for the Lontin, as it was innocent of intentional illusion; but the public was impatient for "divisibility," and subdivision of that kind fell short of its expectations. It had seen the Suisse candle in the entrance hall; had *heard* it too; and that was enough. The Rapieff light had a thoroughgoing advocate behind it; but, if that was the fizzing creature which threatened its globe with imminent explosion early in the evening, its counsel must go elsewhere to seek a favourable verdict. The principal light of the evening, too, in spite of its illustrious owner being in the chair, behaved in a most wilful manner; and, as to the much-talked-of Edison light, somebody averred it to be non-existent, and the announcement was received with no sign of dissent or regret.

Was Electric Lighting, then, a mere luxury, an expensive toy, forced into a brief display by the caprice of fashion? Well, in truth, partly so; yet not entirely. For was not the Hall itself illuminated by a single lamp which far surpassed anything that acres of gas could accomplish, both in purity, brilliancy, diffusiveness, and even in steadiness—when it chose to do its best? Then there was the moderator lamp of Rapieff, highly ornamental, and suggestive of drawing-room domesticity. Its magnificent light was all that could be desired—and, if the truth must be told, a great deal more; in other words, there was no mistake about the electrical development or the amount of light, but there had been some misconception as to their docility and distribution. One Siemens' lamp overhead was more than sufficient to light up a place half as big again as the Hall in which it was suspended; but people do not want a lighthouse in their dwellings, nor burning splinters shot down on their carpets—to say nothing of the sickly smell of burning grease which arose from the engine room, and pervaded every corner of that sanctuary of the Arts during the whole evening.

What, then, was the net result of this exhibition? We have shown that it was incomplete, several lamps which claim to give an agreeable and reliable light being discreetly absent, and those that were shown labouring under the disadvantage of a rough

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trial. But general conclusions were drawn; and for the bulk of the people present those conclusions were legitimate. They might be summarised as follows:—That the eletric light would be good for, and cheap enough for, large spaces; that it would give light for purposes which gas scarcely pretends to do, or, at any rate, does in a very imperfect manner, and in not a few places where gas has no function at all; that for ornamental and festive occasions it will be unique, and cheap at any price; that for street illumination its chances, depending upon cost, have yet to be ascertained; and that for general distribution it, at present, holds out no promise whatever. The candour of several gentlemen, themselves well-known promoters of electric lighting, was most praiseworthy. While they expected and hoped for great and rapid improvements in their own field of work, they declined to countenance a crusade against gas. One of these gentlemen, interested in a lamp which for general utility stands amongst the foremost, expressed a wish that he owned a lot of gas shares, and had money to buy more. Some unlooked-for and fundamental discovery in the capabilities of electricity for lighting purposes will have to be made before that sort of confidence in the stability of gas can be seriously shaken. At least, that was the impression which the people assembled to witness the first public performance of its rival carried away with them.

SUBMARINE TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Although I cannot claim to have had much personal experience of the actual working of submarine cables, I have long felt that there was great need of improvement, and that the first important step should be to devise means whereby the discharge of the conductor could be effected in a time not longer than that of the charge, whatever the latter might be. Of course, the use of condensers has been of great service, but the duration of the discharge of the conductor is thereby increased rather than diminished. It is therefore desirable to dispense with the use of condensers, and this I think quite possible. Perhaps, you will allow me to make some general remarks on the charge and discharge of electricity in submarine cables, and to solicit any correction of my statements which your readers may consider necessary.

1. It is an established fact that the speed of transmission of intelligible signals through a conductor depends upon the rapidity with which the discharge of the conductor can be effected, or, in other words, upon the time necessary to restore a conductor to its neutral state.

2. Experience has proved that, when a conductor has received its maximum charge, and then its communication with the battery be severed, and it be put in communication with the earth at one end only, the duration of discharge is four times longer than that of the charge.

3. The cause of this disparity between the duration of charge and of discharge appears to be that, whereas the charge is made under a constant force, namely, that of the battery, the discharge is made under a constantly decreasing force—the maximum of the latter can never be greater than that of the constant force.

4. Experience has also proved that, when both ends of a conductor are put in communication with the earth simultaneously after severance from the battery, the duration of the time of charge and of discharge is the same, provided the conductor has received its maximum charge. The reason is that the discharge being made at both ends diminishes the time of discharge in the same ratio as it is increased by the constantly decreasing force.

5. When the time of the charge is diminished by diminishing the duration of the contact with the battery, the conductor receives a portion only of its maximum charge, yet the time of discharge in the case when both ends are put to earth remains the same as when the conductor had received its maximum charge, because in all cases the charge is made under a constant force, and the discharge in all cases is effected under the same conditions, that is under a constantly decreasing force.

6. It is, therefore, evident that the speed of transmission cannot be increased simply by diminishing the duration of the time of contact with the battery with the conductor.

7. The great obstacle to the increase of speed of transmission of intelligible signals is the sluggishness of the discharge of the conductor; and, to increase this speed beyond that attained when the conductor has attained its maximum charge, it is necessary to reduce the charge (which is easily accomplished by reducing the time of contact of the conductor with the battery) and to reduce the time of discharge; and this, I submit, is the great problem to be solved—how to reduce the time of discharge?

8. It is well known that currents of opposite kinds of electricity neutralise each other when they meet in a conductor and restore it to its neutral state.

9. Whereas the difference between the times of charge and of discharge is caused by the fact that the charge is made under a constant force and the discharge is made under a constantly decreasing force, it is evident that the application of a force to effect the discharge equal to the force under which the charge is made will cause the discharge to be made in the same duration of time as that of the charge, whatsoever that duration may be.

10. When a conductor, after it has received a charge, is separated from the battery, and is put to earth at the sending end, the other end being to earth, the charge in the conductor divides itself at the centre of resistance, and one part of the charge returns to the earth at the sending end, and the other part flows on to the earth at the receiving end, and the duration of discharge at each end is equal to the duration of that of the maximum charge, although the charge may have been only a fraction of the maximum charge, and the two discharge currents flow in opposite directions in the two portions of the conductor from the centre of resistance precisely in the same manner as if the conductor was severed at the centre of resistance.

11. The principle that currents of opposite kinds of electricity neutralise each other has been applied with success at the sending end, and by this application that portion of the conductor on the side of the centre of resistance next to the sending end is discharged, or, in other words, restored to its neutral condition, and the duration of the discharge of this portion of the conductor will not be longer than that of the charge, because the discharge will be made under a force similar to that which effected the charge.

12. Although by the application of neutralising currents the discharge at the sending end of a portion of the conductor is made in a time not longer than that of the charge, yet the discharge of the other portion is made at the receiving end under a constantly decreasing force, and the duration of that discharge remains at its maximum whether the charge had attained its maximum or only a fraction thereof, consequently the speed of transmission remains the same as when the maximum charge had been received.

13. In order to discharge, or, in other words, to restore to its neutral condition that portion of the conductor next to the receiving end, it is necessary to employ a constant force, namely, a battery, by which a current of opposite kind to that of the charge can be sent into the conductor.

14. The deduction from these facts is that, when a conductor has received a charge of one kind of electricity, and is then put to earth at both ends, and also a charge of the opposite kind of electricity is sent into it from both ends, the conductor is restored to its neutral state in a duration of time, not longer than that of the charge, whatever that duration may be and, therefore, by this means the maximum speed of transmission of separate and distinct shocks or waves of electricity is obtained.

15. I am not aware that any arrangement has been heretofore made by which a current of negative electricity enters the cable at the receiving end simultaneously with a current of the same kind at the sending end, and thus the charge of positive electricity in this portion of the cable is neutralised.

16. The charge sent into the cable from the sending end does not act on the receiving instrument in an increasing tension, but only when it has attained the tension required, which is regulated by means of a rhéostat, and then it acts suddenly with its full force, and it ceases to act suddenly. Hence the marks on a special paper begin and end squarely. At the same time, so soon as the required action on the receiving instrument ceases, the discharge of the cable is completed, not through the receiver, but through another channel to the earth. The device by which these arrangements may be secured I will withhold for the present.—I am, sir, your obedient servant, RICHARD HERRING.

27, St. Mary's-road, Canonbury, 17th Dec., 1878.

ANSWERS TO CORRESPONDENTS.

THOS. METCALFE.—Perhaps, your "powerful magneto-electric machine" will not ring the electric bell because the former is arranged to supply a rapid succession of currents alternately in opposite directions. Or, perhaps, the electro-motive force of the machine is lower than that of the "weak" battery, and insufficient to transmit through the resistance of the bell a current that will actuate the electro-magnet.

B. (Plymouth).—The Leclanché cell constitutes one of the very best *wailing* batteries, and it is neither necessary nor desirable to remove the porous cells from the solution. On the contrary, they should never be allowed to get dry when once they have been immersed in the latter; and, for this reason, water should from time to time be added to the contents of the cell. It might preserve the zincs a little to remove them as proposed, since they are liable to become corroded at the line where they are in contact both with air and fluid.

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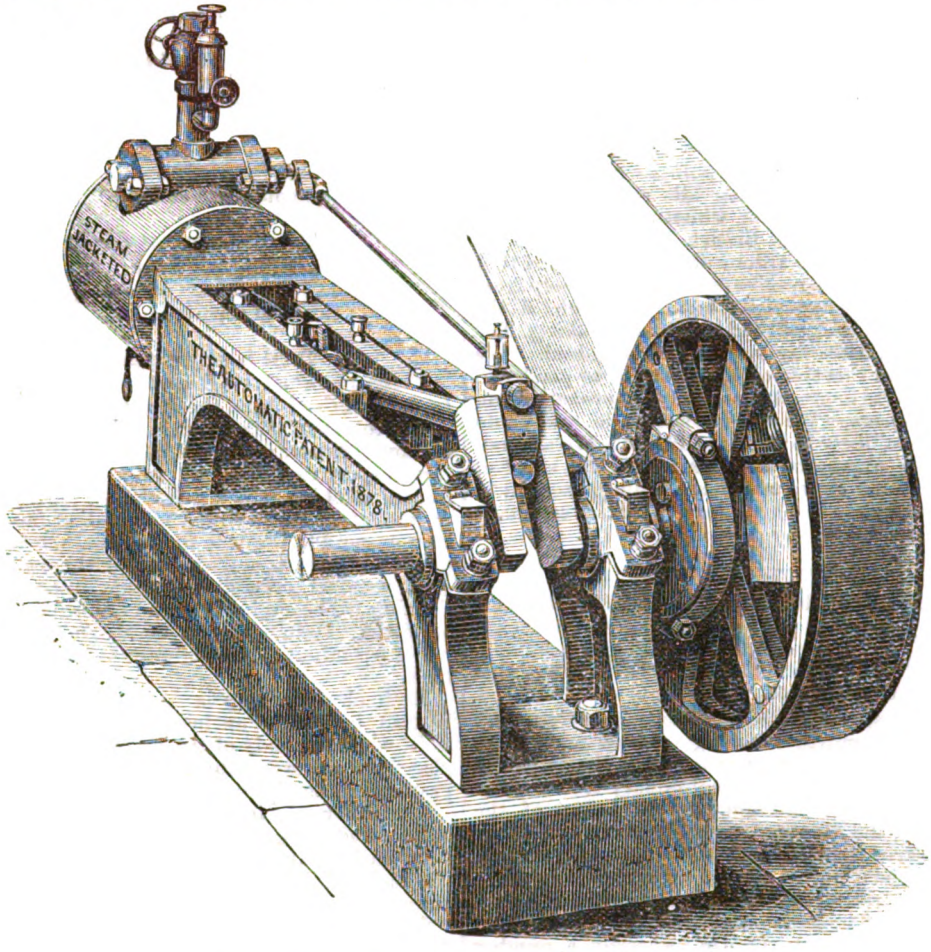
THE MOTIVE POWER TO DRIVE DYNAMO-ELECTRIC MACHINES.

In our last number we described an engine designed by Messrs. Ransomes, Sims, and Head. It is not, however, always necessary to have so complete an apparatus. In many cases, and especially is this the case in large factories, there is a sufficient boiler power to generate the steam, so that more boiler power is not wanted for the special engine required for lighting purposes. Instead, therefore, of going to the expense of obtaining a boiler and engine, in such cases the engine only is required. If there is the slightest doubt as to the supply of steam, we should advise in all cases a good margin on the safe side. The supply of steam being provided for, the engine has to be obtained and fixed. An engine seemingly suitable for this purpose we illustrate below. The manufacturers of the engine call it "The Automatic," and claim several advantages for it. One of the most important for electrical engineers to consider is the governor. The makers state that the "automatic variable expansion," which governs direct, without requiring a throttle valve, ensures great economy of steam by admitting the exact amount required by a varying load, and thus keeping the machine running with extreme steadiness. As will be seen from our illustration, the engine is extremely simple, and an endeavour has been made to concentrate in one engine the most important improvements of recent years. The cylinder is steam-jacketed, steel and phosphor bronze are used instead of wrought iron and brass, so that the wear of bearings may be reduced to a minimum, and that the maximum strength may be obtained from the use of the least weight of material. According to the statements of Messrs. C. Russell and Co., the 10-horse power nominal, with 60 lbs. boiler pressure, works to 30-horse power indicated. The diameter of the cylinder of this engine is 10in., length of stroke 16in., diameter of fly-wheel 42in., making 120 revolutions per minute. Supposing a small Gramme to be driven direct from the fly-wheel without any intermediate shafting, we should obtain some 840 revolutions of the dynamo machine per minute. This would be about the number of revolutions the machine would be required to make under ordinary circumstances. At the experimental shed on the Embankment the small Gramme does not make so many revolutions as this, but in other cases it is required to make 900 or 1,000 revolutions per minute. It would be well, perhaps, to caution engineers against too high a rate of speed. The dynamo machine will, like other pieces of mechanism, heat if driven too fast, and past a certain point the wires will fuse, rendering the machine useless. In fixing the engine to drive the machine, as well as in fixing the machine itself, it is necessary that great care should be taken to have a good firm foundation. Messrs. Russell make the engine we have thus briefly mentioned of sizes varying from 1 to 10-horse power. If required, Messrs. Russell supply the necessary boilers to generate steam for any size machine.



A RESPONSE BY MR. PREECE TO CRITICISM ON HIS DEFENCE OF THE BRITISH POSTAL TELEGRAPH MANAGEMENT.

TO THE EDITOR OF THE (AMERICAN) JOURNAL OF THE TELEGRAPH.

I really must protest against the assumption that the official monopoly of the telegraphs in England has discouraged invention by the difficulty of obtaining recognition or adoption. In the first place, the monopoly itself is a myth. The telegraph system outside the Post Office is as great now as was that of all the private companies together before the transfer. Every railway company has its own distinct and separate system. The international and inter-colonial business of England is transacted by private enterprise. All our colonies have their own self-managed departments, and the British Post Office is only one member of a large fraternity. There are several independent private wire companies. The Exchange Telegraph Company of London is as much so as your District Company in New York. So it is a fallacy to assert that there is a monopoly of telegraphs in England.

Can any inventor be produced—except, of course, Mr. Herring, who is irrepressible—who has not had fair play from the Department? * Did red-tapeism prevent or even retard the trial and adoption of the duplex and the quadruplex? Are there any lines in the world which convey more messages or work faster than

* The carbon telephone failed utterly to work on our wires, and the reason given is that the officials of the British Post Office were interested in the Bell telephone, and would not let it work. The Bell telephone also would not work, but I have not yet learned that the same ingenious reason for failure has been invented.

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ours? Are we behind any administration in technical efficiency or scientific experience?

The proof of the pudding is in the eating thereof, and if you only test us by results we do not fear the enquiry.

I fear that the truth is that in making us out to be behind the spirit of the age the wish is father to the thought; otherwise you would scarcely reproduce in such an excellent journal "the hairbrained chatter of anonymous frivolity."

My paper was written to establish three propositions:—

1. Greater improvements have been made in telegraphy during the past eight years than in any previous period of similar duration.

2. Inventions have not only found their way here from America, but have also travelled in the opposite direction.

3. Improvement in telegraphy was never more active in England than it has been since the Government has controlled the telegraphs.

No propositions could be more simply enunciated, nor to my mind more emphatically proved, but up jump a crowd of critics who evolve from their inner consciousness entirely different propositions, and proceed, with much satisfaction to themselves and amusement to me, to demolish them. I cannot deal with such critics. If my propositions have not been proved, in what points do my arguments fail? If my facts or my arguments are wrong, I am ready to admit my error, but how can I be expected to defend what I never asserted?

The propositions my critics imagine and then demolish are:

1. All recent improvements in telegraphy have emanated from the British Post Office.

2. The monopoly of the telegraphs by the State has *stimulated* invention.

3. England is quite independent of foreign countries, and especially of America, for developing improvement.

I quite concur in the fallacy of these points with my critics. All I contend is that we are not standing idle on the housetops with our hands in our breeches pockets, whistling for winds that come from other quarters; that the British Post Office has not checked invention nor cooled the ardour of inventors; and that we are quite willing and ready to receive assistance and help from any one and every one, and especially from your side of the water. We are not jealous of the great strides you are making. The conditions of the two countries are very different indeed. We have no paid inventors on this side of the Atlantic to pander to popular enthusiasm, and to depreciate property by promulgating the discovery of mares'-nests. We report what we do, and we do not discount what we are likely to do in the future. We are content to improve as we go along, to keep pace with the spirit of the age, and to maintain, as we are maintaining, the lead in cheap and swift telegraphy.

W. H. PREECE.

London, Nov. 14th, 1878.

ON THE PRACTICAL APPLICATION OF ELECTRICITY TO LIGHTING PURPOSES.*

By JAMES N. SHOOLBRED, B.A., Mem. Inst. C.E.

(CONCLUDED FROM PAGE 48.)

3rd Stage.—Paris, Lyons, and Mediterranean Railway Company.—Paris Terminus.—This company, having decided to try the effect of the Lontin electric light, gave permission to the patentees of that system to enter upon a period of preliminary trial at their passenger station, to enable the company to judge of the efficiency and economy of the illumination before finally adopting it. Twenty-eight electric lights distributed about the station, and replacing 172 gas jets, were supplied with electricity by a combination of one generating and two dividing machines all upon the Lontin system. The lamps used were the modification of the Serrin, introduced by M. Lontin, whereby a number can be employed upon one circuit (where only one of the original Serrin can be used). The power of each of these dividing machines was that known as of "18,000 candles." The motor power for this temporary arrangement was a Brotherhood 3-cylinder engine, supplied by steam from an old locomotive (lent by the railway company). This arrangement proved, however, to be wasteful in steam. The effective illuminating power of each electric lamp was considered to be equal to that of 80 gas jets. The average cost of the 28 electric lamps during these preliminary trials would appear to have been about 8s. 2d. (10·25 francs) per hour. This preliminary experience lasted from September 7th to October 28th, 1877. The result was, however, sufficient to satisfy the railway company as to the effectiveness of electric illumination, and as to the possibility of its being carried on without interruption, and it induced them to enter into a contract with the patentees of the Lontin system to light up for a period of twelve months a large receiving shed in their goods station of the same terminus. Twelve lights were to be provided, all emanating from one dividing machine. The total cost per hour was 5s. (6 francs), or 5d. (0·50 franc) per light, the contractors finding everything requisite, except water, and bearing all working expenses.

Western of France Railway—Paris Terminus, St. Lazare.—This railway decided, in the early part of 1878, to try the Lontin system of electric lighting at this station.

Goods Yard.—The patentees of this system commenced, in May last, to light up the goods yard, on the arrival side. For this purpose, six electric lights are placed against the columns which carry the roof, at a height of about 12ft. from the ground. They are provided with electricity from a Lontin (double) machine, of the type known as of "12,000 candles."

The motor power being afforded by an agricultural engine of horse power nominal, the piston being 9½in. in diameter and 13½in. stroke, the average pressure in the boiler being 83lb. per square inch, and 110 the average number of revolutions per minute of the fly wheel—the total hourly consumption of coal per hour being about 80lb.—the lights were found, by a series of careful experiments (of which later on), to be of a mean luminous intensity of 480 candles each. They are generally left naked, without any shade, without any ill effect being produced upon the persons below.

The lamps used are the Serrin, modified by Lontin, so as to admit of several being placed upon one circuit; in this instance they are placed in pairs, six lamps upon three circuits. The consumption of the ⅜-in. round carbons was found to be at the rate of 1½d. per light per hour.

The average working expenses of these six lights are, per hour—

Coal, &c., for engine, at 32s. per ton...	1s.	2d.
Carbons for six lamps		8d.
Engineman and stoker		10d.
Total hourly cost for six lamps ...	2s.	8d.
Or, per light per hour		5½d.
Add for interest on outlay for depreciation and repairs		2½d.
Total hourly expense of each light ...		8d.

Passenger Station (Department side), Salle des Pas Perdus.—In the month of June the directors of the railway company determined to extend the electric illumination to this portion of the station. Accordingly, the patentees of the Lontin light fixed for this purpose twelve lights, supplied from an "18,000 candles" Lontin machine, which was placed, together with an agricultural engine of 12 horse-power nominal, at first in the cellars of the station, near to the Rue St. Lazare. It was afterwards removed up on to the station itself in a shed constructed for the purpose. This removal necessitated some interruptions in the regular lighting. The engine is of the following dimensions:—Diameter of piston, 11⅞in.; length of stroke, 13in.; revolution of fly-wheel per minute, 110; average boiler pressure, 93lbs. per square inch.

Each electric lamp is enclosed in a ground glass circular lantern, in form of an inverted truncated cone, with a metal top to it, while the body of the lamp protruding below the lantern is placed in an ornamental bronze case, the whole having an appearance of an elegant moderator lamp.

The difference in the illumination between this side of the station and the goods yard side, where the lights are naked, is very marked, and leaves an impression very much in favour of the enclosed light, which diffuses the illumination and renders it more uniform. Very fine is the effect in the large hall called the "Salle des Pas Perdus," which is 445 feet long, 66 feet wide, and 20 feet high at eaves, and nearly 40 feet at ridge. Five lamps from the centre, suspended at an elevation of about 18 feet from the ground, light up this fine hall.

The twelve electric lights in this part of the station are placed upon three circuits, four lamps upon each.

Street Lighting in Paris.—The Jablochkoff "Candle."—Of the various streets and other places lit up by this system, the Avenue de l'Opéra is the one which, from its central position, has attracted most attention, and, therefore, will be taken here as a typical example.

The Avenue de l'Opéra, including the Place de l'Opéra, at one part, and the Place du Théâtre Français, are lit up by 62 lights; 46 single candle and eight double candle (on the Place de l'Opéra). Originally only about 40 were provided, but the illumination being insufficient, the number was augmented (at the contractor's expense) to the amount just stated.

These are divided into four groups; one on the Place de l'Opéra, two in the Avenue de l'Opéra, and one on the Place du Théâtre Français. Each group of lights is supplied with elec-

* A Paper read at the Society of Arts, 4th December, 1878.

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tricity from a (double) Gramme "16 light" machine, driven by an engine of 20 nominal horse-power.

A very considerable amount of mystery has been kept up by the patentees of this system as to the cost of it. The expense, they state it to be, is (1·06 francs) 11*d.*, nearly, per light per hour, which they hope, so it is said, shortly to reduce by one-half. However, the payment to the patentees by the City of Paris is at the rate of 1·25 francs per hour on each of the original lights stipulated in the contract, the augmentation to 62 being entirely gratuitous by the contractor, and in order to keep up an effective illumination. The total remuneration is 37·2 francs (40*s.*) per hour. The original gas illumination consisted of 344 jets, and cost 7·224 francs (6*s.*) per hour. The electric illumination is considered, however, as equal to 682 gas jets, say, to double the original illumination; that is, to a cost of 14·45 francs per hour, as against 37·2 francs for the electric one. The latter, therefore, cost 2·6 times that of the gas of equal illuminating intensity.

Need it be added that the City of Paris have terminated the contract with the last day of November.

The contractors have, however, offered to continue the contract at the reduced rate of 0·60 francs (6d.) per light per hour. The Municipal Council of Paris have declined to continue any contract, except provisionally, up to January 15th, 1879, and that only at the rate of the original cost of the gas, viz., at a total expense of 7·224 francs (6s. nearly) per hour. By information lately received from Monsieur J. Allard, the chief engineer of the lighting department of the City of Paris (under the engineer-in-chief, M. Alphand), and by whom the above details have been kindly communicated, the contractors for the lighting, the Societé Générale d'Electricité, have consented to undertake the lighting at the above reduced rate. The price paid to them, therefore, will be, up to January 15th next, at the highly remunerative rate of about 1½d. per light per hour, for what, on their own statement, costs 11d. Pleasant news for the shareholders of the Société Général d'Electricité.

A series of very careful photometric measurements, carried out by the municipal authorities in the Avenue de l'Opéra itself with the existing illumination, showed each light to possess a maximum of 300 candles of intensity with the naked light; while by the interposition of the opaque globe the maximum was reduced to 180 candles (a loss of 40 per cent.), and this again to a minimum of 90 candles during the darker periods through which this light passed.

Many other applications of the Jablochkoff candles with the Gramme machine occur in Paris, such as at the Magazins and the Hôtel du Louvre, at the Théâtre du Châtelet, at the Hippodrome, at the Hôtel Continental, &c. Still, as in none of these cases have the financial results been ascertained on such good authority as in the case of the Avenue de l'Opéra, it has been thought advisable to pass them over. Since the main object, held constantly in view in the present communication, has been to ascertain the carefully prepared financial results of a few applications, which have been supplied on unimpeachable authority, rather than to attempt to present those of a larger number, some of which results might have been open to doubt.

Rapieff Light at The Times Office, London.—So much attention has, in this country at least, been drawn to this, one of the latest novelties in the application of the electric light, an interest due mainly to the peculiar form of lamp used in conjunction with the Gramme machine, that one can hardly conclude this brief notice of electric light applications without saying a short word about it. A Gramme (double) "16 light" machine has been provided at *The Times* office by the proprietors, together with an engine suitable even for future emergencies, and a portion of the lights, six in number, in the machine room, all in one circuit, have been set in place. A much larger addition to the number, in other parts of the building, is shortly contemplated.

Owing to the fact that only a portion of the intended application has so far been got to work, and that only recently (since October 12th last), it is not possible, nor hardly fair, yet to judge of the actual results. Still the system works fairly and with regularity, which cannot be said of all others, and it may, therefore be entitled to take rank as an established application of electric illumination.

In the preceding remarks on the various applications of electric lighting to illuminating purposes, many, very many, of a highly interesting character have been omitted. Amongst these might be named for military and naval purposes, for the construction of large works out of doors, such as docks, bridges, &c., for cocooning and spinning operations (where the purity of the electric light is of peculiar advantage), for agricultural and other classes of night work, too numerous even to name. This omission has been necessitated partly from want of time, partly from want of those very careful and even scientically prepared results which were desired. It is hoped, however, that the few and carefully selected examples presented will afford some slight guide as to the results, financial and otherwise, which effective electrical illumination may be expected to afford.

ON THE ILLUMINATION OF LINES OF MOLECULAR PRESSURE, AND THE TRAJECTORY OF MOLECULES.*

By William Crookes, F.R.S., V.P.C.S.

Induction Spark through Rarefied Gases. Dark Space round the Negative Pole.

The author has examined the dark space which appears round the negative pole of an ordinary vacuum tube when the spark from an induction coil is passed through it. He describes many experiments with different kinds of poles, a varying intensity of spark, and different gases, and arrives at the following propositions:—

Illumination of Lines of Molecular Pressure.

a. Setting up an intense molecular vibration in a disk of metal by electrical means causes a molecular disturbance to proceed from the surface of the disc to the surrounding gas. When the gas is dense, the disturbance only extends a short distance from the metal, and, as rarefaction proceeds, the layer of molecular disturbance increases in thickness. In air at a pressure of ·078 millim. this molecular disturbance extends for at least eight millims. from the surface of the disc, forming an oblate spheroid round it.

b. The diameter of this dark space varies with the exhaustion; with the kind of gas in which it is produced; with the temperature of the negative pole; and, in a slight degree, with the intensity of the spark. For the same degree of exhaustion it is greatest in hydrogen and least in carbonic acid, as compared with air.

c. The shape and size of this dark space do not vary with the distance separating the poles; or, except very slightly, with alteration of battery power; or with intensity of spark. When the power is great the brilliancy of the rest of the tube overpowers the space, and renders it difficult to observe; but, on careful scrutiny, it is seen to be there unchanged in size. With a very faint spark the space is still present, unaltered in dimensions, although scarcely visible; and if the power is still further diminished, it fades out altogether, without change of shape.

The author describes numerous experiments, devised to ascertain if this visible layer of molecular disturbance is identical with the invisible layer of molecular pressure or stress, the investigation of which has occupied him for some years.

The Electrical Radiometer.

One of these experiments is as follows:—An ordinary radiometer is made, with aluminium disks for vanes, each disk having a film of mica close to one side. Instead of a glass cup, the fly is supported by a hard steel cup, and the needle point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer can therefore be connected with an induction coil, and the movable fly be made the negative pole.

Passing over the phenomena observed at low exhaustions, it is found that, when connected with the coil, a halo of a velvety violet light forms on the metallic side of the vanes, the mica side remaining dark throughout these experiments. As the pressure diminshes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millim., this dark space extends to the glass, and positive rotation commences.

On continuing the exhaustion, the dark space further widens out and appears to flatten itself against the glass, the rotation now being very rapid.

When aluminium cups are used, instead of disks backed with mica, for the vanes of a radiometer, similar appearances are seen. The velvety violet halo forms over each side of the cup. On increasing the exhaustion the dark space widens out, retaining as much as possible the shape of the cup. The bright margin to the dark space becomes concentrated at the concave side of the cup to a luminous focus, and widens out at the convex side. On further exhaustion, the dark space on the convex side touches the glass, when positive rotation commences, becoming very rapid as the dark space further increases in size, and becomes flattened against the glass.

Convergence of Molecular Rays to a Focus.

The subject next investigated is the convergence of the lines of force to a focus, as observed with the aluminium cup. As this could not be investigated when in rapid rotation, an instrument was made, having the cup-shaped negative pole fixed, instead of movable. On exhausting, the convergence of the lines of force to a focus at the concave side was well observed. When the dark space is very much larger than the cup, it forms an irregular

* Abstract of a Paper read before the Royal Society.

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ellipsoid drawn in towards the focal point. Inside the luminous boundary a focus of dark violet light can be seen converging, and as the rays diverge on the other side of the focus they can be seen spreading beyond the margin of the dark space; the whole appearance is strikingly similar to the rays of the sun reflected from a concave mirror through a foggy atmosphere.

Green Phosphorescent Light of Molecular Impact.

At very high exhaustions the dark space becomes so large that it fills the tube. Careful scrutiny still shows the presence of the dark violet focus, and the part of the glass receiving the rays diverging from this focus shows a sharply defined spot of greenish yellow light. On still further exhaustion, and especially if the cup is made positive, the whole bulb becomes beautifully illuminated with greenish yellow phosphorescent light.

This greenish yellow phosphorescence, characteristic of high exhaustions, is frequently spoken of in the paper. It must be remembered, however, that the particular colour is due to the special kind of soft German glass used. Other kinds of glass phosphoresce of a different colour. The phosphorescence only takes place under the influence of the negative pole. At an exhaustion of four millionths of an atmosphere,* no light other than this is seen in the apparatus. At ·9 M the phosphorescence is about at its maximum. When the exhaustion reaches ·15 M the spark has a difficulty in passing, and the green light only appears occasionally in flashes. At ·06 M the vacuum is almost non-conductive, and a spark can only be forced through by increasing the intensity of the coil, and well insulating the tube and wires leading to it. Beyond that exhaustion nothing has been observed.

Focus of Molecular Force.

In an apparatus specially constructed for observing the position of the focus, the author found that the focal point of the green phosphorescent light was at the centre of curvature, showing that the molecules causing it are projected in a direction normal to the surface of the pole. Before reaching the best exhaustion for the green light, another focus of blue-violet light is observed; this varies in position, getting further from the pole as the exhaustion increases. In the apparatus described, at an exhaustion of 19·3 M, these two foci are seen simultaneously, the green being at the centre of curvature, whilst the blue focus is nearly twice the distance off.

(TO BE CONTINUED.)

HYGIENIC EFFECTS OF THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the discussion upon the paper read by Messrs Higgs and Brittle at the Institution of Civil Engineers, entitled "Some Recent Improvements in Dynamo-electric Apparatus," Mr. Preece seems to have made an absurd statement with regard to the amount of fresh air consumed by the Post Office officials. I give his words:—"At the Post Office there was a large hall occupied in the transaction of telegraphic business, where between the hours of 4 p.m. and 8 p.m. in the winter, when gas was burning, a staff of six hundred persons was employed. Those six hundred persons consumed 1,800,000 cubic feet of fresh air per hour," etc., etc. This gives 3,000 *cubic feet of fresh air per hour per official*. Liebig, however, gives 15·8 cubic feet of fresh air per hour per adult, considering the air as irrespirable when 1-3rd of the constituent oxygen is consumed. Hoping for some explanation, I remain, yours, &c.,

L. A. DAVIES.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Dec. 18.		Business Done Week Ending Dec. 18. Highest.	Lowest.
Anglo-American	57,	¼	58⅛	57
Do. "B"	83¼,	4	85⅜	84
Do. "A"	32,	¼	33⅛	32
Brazilian	6¼,	⅛	6⅜	6 9-16
Cuba	8½,	¼	—	—
Do. Ten per Cent. Preference	15,	½	—	—
Direct Spanish	2,	¼	—	—
Do. Ten per Cent. Preference	9¾,	10½	9¾	9½
Direct United States	11¼,	⅛	12⅛	11⅜
Eastern	7⅛,	⅛	7⅛	7⅛
Do. Six per Cent. Debenture	101,	4	102¾	100
Do. Five per Cent. do.	100,	2	100⅜	—
Do. Six per Cent. Preference	10⅞,	11	10⅞	—
Eastern Extension	6 15-16,	7 1-16	7⅛	6⅞
Do. Six per Cent. Debenture	10½,	7	—	—
German Union	8,	½	—	—
Globe Telegraph and Trust	4¾,	5	5	4⅞
Do. Six per Cent. Preference	10½,	⅛	10⅛	10⅜
Great Northern	7⅞,	8	7⅞	—
Indo-European	19,	20	—	—
Mediterranean Extension	2¾,	3	—	—
Do. Eight per Cent. Preference	8¾,	9½	—	—
Reuter's	10,	11	10	—
Submarine	217,	22	—	—
West India and Panama	1⅞,	2	2	1⅞
Do. Six per Cent. Preference	7⅞,	8	8	7⅞
Western and Brazilian	2⅛,	⅛	—	—
West. Union Seven per Cent. 1st Mort.	114,	18	—	—
Do. Six per Cent. Sterling	100,	2	—	—

* M signifies the millionth of an atmosphere.

TRAFFIC RECEIPTS FOR NOVEMBER, 1878.

Companies.	Nov. 1878.	Nov. 1877.	Increase.	Decrease.
Anglo-American Telegraph Company	£51,090	£47,890	£3,200	—
Brazilian Submarine Company	12,753	12,233	520	—
Cuba Submarine Company	2,600	2,859	—	259
Direct Spanish Telegraph Company	1,001	885	116	—
Direct United States Telegraph Company	17,030 estd.	12,920	4,110	—
Eastern Extension Telegraph Company	25,280	20,794	4,486	—
Eastern Telegraph Company	37,170	38,439	—	1,269
Great Northern Telegraph Company	16,587	17,670	—	1,083
Submarine Telegraph Company	9,549	9,817	—	268
Western and Brazilian Telegraph Company	—	11,226	—	—
West Coast of America Telegraph Company	2,200	1,800	400	—
West India Telegraph Company	4,676 estd.	4,294	382	—

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J. P. BEDFORD, *Secretary, pro tem.*

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NOTES.

THE "DIP" OF THE MAGNETIC NEEDLE.—This property of the needle was discovered by Robert Norman, about the year 1576.

A NEW CABLE.—We learn from Madrid that a royal decree has been published authorising the Minister of the Colonies to accept proposals for laying a submarine cable between Manilla and Hong Kong.

WILDE'S MACHINE AND LAMP.—Owing to the Christmas holidays, and having to go to press several days earlier than usual, we are unable to do more than mention that Mr. Wilde has designed a new dynamo machine and a lamp for electric light purposes, which have been satisfactorily tried at Westminster.

POOLE AND THE ELECTRIC LIGHT.—We understand that in the experiments with the electric light a gentleman was sufficiently interested in the question to take diagrams in order to ascertain the horse power really used. We believe the indication was that the Wallace-Farmer machine took twenty horse power nominal, with four lamps in circuit. Some people are in a great hurry to burn their fingers.

ELECTRICITY AND TELEGRAPHY.—We are informed that the French Telegraph authorities have decided to open a school in February for instruction in matters connected with Electricity and Telegraphy. This step is rendered necessary in consequence of the union of the French postal and telegraph services, the working of which is not satisfactory. The course of lessons will extend over a period of five months, and each session will be terminated in time for the examination appointed by the authorities. We shall watch with great interest the development of this matter, and hope shortly to give our readers a full account of its working.

A CONDENSER OF VARIABLE CAPACITY.—This condenser, as described at the meeting of the Physical Society, November 14, was stated to have been designed for use in connection with the Holtz electrical machine, to show the effect of condensation on the length of the spark. It consists of a test-tube coated externally with tinfoil to form the inner armature, and a glass tube enclosing the test-tube, and having its outer surface covered with tinfoil for the outer armature. The inner tube can be slid out or in along the length of the external tube, and the capacity thereby varied. Professor Guthrie showed that a spark from the Holtz machine could by its means be gradually reduced.

EDISON'S PATENT.—It will be remembered that there was an opposition to this patent filed. A preliminary hearing of the case took place at the House of Commons on Monday, December 16th, when Mr. Russell was ordered to pay all costs, and an adjournment was then granted to enable him to file evidence in support of his objection. This was done by declarations from Messrs. Russell, Haddon, and Knowles, and replied to by Messrs. Adams and Walenn. The result of the proceedings on Friday, 20th December, was a decision that the application of Mr. Edison for a patent should be allowed to proceed, and that the costs now incurred should be paid by Mr. Russell. Mr. Edison was represented, as on Monday, by Mr. Theodore Aston, Q.C., instructed by Messrs. Brewer and Jensen, patent agents, of Chancery-lane. Unless further opposition should be offered, it may be expected that in a few days Mr. Edison's patent will be sealed.

A SCEPTIC ON EDISON'S ELECTRIC LIGHT.—The *Mining Journal* says:—"The telegram received from New York to the effect that the essential feature of Mr. Edison's alleged discovery of an improved electric light is the production of the light by the incandescence of an alloy of platinum and iridium affords conclusive proof that the invention is worthless, or rather no invention, since precisely the same method of producing the light was invented thirty-three years ago, and has, according to M. Fontaine, the well-known French electrician, been constantly used in lecture experiments ever since, although it has never given satisfactory results for illumination. If Mr. Edison has produced a light strong enough to read by with incandescent iridio-platinum and one Daniell cell, the size of this cell must have been larger than any yet seen."

INGENIOUS APPLICATION OF ELECTRICITY IN THE ARTS.—A new and useful application of electricity has been made by an American inventor to the apparatus for reeling silk from the cocoon. The delicate filaments of silk are carried over wire arms, which are so nicely balanced that they do not press against the silk strongly enough to break it, and in this relation a current is kept open; but, if the filament breaks, the arm falls, the circuit is closed, and an electro-magnet instantly stops the reel until the break is repaired. As the work is now done, the detection of a broken filament depends entirely upon the skill of the workmen, and the work must be carried on slowly that the eye can note any break, while with this automatic stop it is said the labour will be much more rapidly done, and a more uniform thread produced. The invention is being introduced into France and Italy, the two great silk-producing countries of Europe.

THE ELECTRIC LIGHT.—The electric light was experimentally used at the London Bridge terminus of the London, Brighton, and South Coast Railway on Saturday afternoon and evening, for lighting the open space between the main line and Crystal Palace line booking offices and the platform barriers. The Gramme machine and Suisse lamp were employed, the motive power being obtained from an engine some 250 yards distant, which, in addition to working the magneto machine, also pumped up the water required for the general purposes of the station. The machine is the first of its kind made in England, and, together with the lamp, which is said to last about twelve hours without attendance, was supplied by the India Rubber and Telegraph Works Company, of Silvertown, whose electrician, Mr. R. K. Gray, and the railway company's telegraph engineer, Mr. E. J. Houghton, assisted by Mr. Carey, carried out the experiment.

THE EXCHANGE TELEGRAPH COMPANY.—This company proposes to publish the *Exchange Telegraph Recorder*, containing the Exchange Telegraph Company's quotations of stocks and shares on the London Stock Exchange, &c. It will supply to those interested in the prices of stocks and shares, not within the radius of the company's telegraphic system, a continuous reliable record of the fluctuations which occur during the day on the London Stock Exchange, and is entirely distinct in character from any

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other publication. The prices quoted in this list will be those obtained in the various markets by the company's special reporters for telegraphic transmission over the company's system of instrumental delivery to subscribers in London. Every fluctuation will be recorded with the time at which it occurs. The want of such a record was fully recognised by Lord Penzance, who, in taking evidence respecting the company's system before the Royal Commission on the London Stock Exchange, suggested that it would be a useful thing for the company to publish a list of its prices in this form for circulation.

THE "SPECTATOR" AND THE PHILOLOGY OF "DUPLEX."—We are in danger of a new barbarism. The phrase "*to duplex*" an electric cable seems coming rapidly into use—in the sense of to make it capable of doing double the work that it did before. But, if that be the meaning, why not use the word "double" itself? "Duplex" means, properly, "twofold," and to propose "to twofold" anything is even less barbarous than to propose to "duplex" it, because it does not naturalise in English a genuinely Latin term. Perhaps it would be said that the word "double" would be misunderstood, and imply adding another cable of equal size. Well, that mistake might just as well be made with the Latin word, and can only be avoided in either the one case or the other by explanations; or, why not say, "to duplify," from the analogy of "simplify?" In any case, "to duplex" is etymological vandalism. Why are such liberties taken with Latin, and never with any living language? Who would venture to speak of "to zweifach" an electric cable? If "to duplex" is right, why not "to simplex" also? Why not say that Mr. Carlyle has "simplexed" his style, or the West End milliners have "simplexed" their fashions?

THE ELECTRIC LIGHT ON THE HOLBORN VIADUCT.—Besides the lamps upon the Thames Embankment, others have been placed on the Holborn Viaduct. There is little to be said of these, except that they are similar to those on the Embankment. The current is supplied by a Gramme machine, driven by a 20-horse power engine (nominal), manufactured by Messrs. Robey. We shall have more to say about this engine in another number; meanwhile, we must again express our regret that some other lamp had not been used. To test a light which has been tested so long in Paris, and to neglect altogether those lights which theoretically possess greater claims to consideration, seems to us to be a case of crass stupidity. If the aim of the "Board of Works" and the "Commissioners of Sewers" had been to prove the inutility of the electric light, they could hardly have gone to work in a better manner. The only first-rate things they have in their experiments are the steam engines employed to drive the dynamo-electric machines. These machines are undoubtedly excellent of their kind, but that the Gramme machine is the best is a conclusion combated on every hand, and, as we say, it would have been better had other machines been tried side by side with those now at work.

PRODUCTS OF COMBUSTION IN THE ELECTRIC ARC.—Mr. T. Wills, F.C.S., has been making some experiments on the production of oxides of nitrogen in the electric arc. The atmosphere, of course, consists mainly of oxygen and nitrogen, but simply in a state of mechanical mixture; if these gases become chemically combined, they form several oxides of nitrogen, most of which are strong and corrosive acids. At a high temperature small quantities of these gases can be made to unite. This is the case when electric sparks are passed through air; also during the combustion in air of a very hot flame, such as that of hydrogen; it therefore seemed probable that, as the temperature of the electric arc is undoubtedly very high, nitric acid, or some other oxide of nitrogen, might be produced by the electric light. The first experiment was rather surprising. A glass cylinder placed over an electric lamp (Foucault's regulator) for two minutes, and afterwards examined, was seen to contain a perceptible amount of red fumes, due to peroxide of nitrogen (N_2O_4). The air surrounding the lamp was next drawn through a solution of potash, and the amount of nitric acid estimated; this gave 10 to 12 grains of nitric acid produced per hour (it may eventually prove to be more, the difficulty being to collect the whole of it). The next step in the research will be to examine the various forms of electric light, with a view to determine the amount of nitric acid produced by each. The subject formed the basis of a communication to the Chemical Society on Thursday, Dec. 19.—*Society of Arts Journal.*

THE VELOCITY OF CANNON BALLS, AND HOW OBSERVED.—Some time ago we witnessed a series of experiments with the 80-ton gun at the Woolwich Arsenal, and had great pleasure in investigating the part played by electricity in these experiments. The following account of the method used in determining the velocity of the projectile is taken from an article describing experiments, in our contemporary, *Nature*:—"The initial velocity of a shot, or, in other words, the rapidity with which a projectile flies at the outset of its career, is now measured by an electrical instrument, the invention of Major le Boulengé, a Belgian officer. As in the case of other instruments of a like nature, the shot is made to break through two wire screens, placed at some distance from one another. The interval is usually about 100 feet. The screen is simply a wooden framework with fine wires zigzagging across, and it is these fine wires which the shot cuts. One screen is near the muzzle of the gun, and the other at the distance we have mentioned. No. 1 screen is in connection with an electro-magnet in the instrument-house, and No. 2 screen with a second, the two magnets hanging close together. While the wires in front of the screen are perfect, an electric current passes without interruption, and the electro-magnets in connection with them are endowed with power, but this power ceases as soon as the shot cuts the wires of the screen. Before the gun is fired there is suspended to the magnets two rods of iron, which remain, however, only so long as the magnets are magnets. When the shot is fired, No. 1 screen is torn, and down falls the rod suspended to No. 1 maguet; an instant afterwards, when the shot has reached No. 2. screen, No. 2 magnet also loses its virtue, and down falls the second rod. The time between the falling of the two rods is so small that, ere the first has fallen half its length, the second has dropped upon a trigger, which trigger darts out and strikes the side of No. 1 rod. When the latter is picked up, the first thing is to examine the surface for the mark of the trigger, for the position of this mark, whether high or low, tells the operator what he wants to know. The rod, being of a given weight, always takes the same time to fall, and according whether it has fallen half or quarter its length, so the time taken by the shot to travel between the screens has been long or short. In a word, the rod has only to be compared with a prepared scale in order to read off the number of feet per second at which the shot has gone on its way."

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ON THE STUDY OF ELECTRICITY AS A PROFESSIONAL PURSUIT.

BY THOMAS T. P. BRUCE WARREN.

(CONCLUDED FROM PAGE 292, VOL. I.)

I propose in the present paper to treat of a few of the commoner materials used by the electrician, and, although I have omitted several substances of special application and interest to the electrician, and have dwelt, perhaps, too briefly with many of these substances, I shall conclude with this the present portion of the subject.

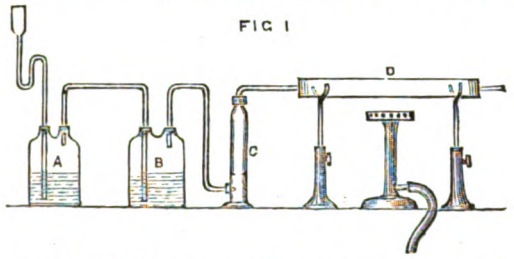
India rubber and gutta percha, the different descriptions of fibres, tar, &c., used for cables, are all worthy of the telegraph engineer's attention from a chemical as well as an electrical aspect.

Zinc from Iron in Alloys.—Galvanised iron. "Bobierre* states that these alloys may be readily and accurately analysed by igniting them in a current of hydrogen."

This method is very convenient for samples of galvanised wire such as may be used for telegraph purposes. Carbonic acid gas cannot be used instead of hydrogen, as the zinc is thereby converted into oxide. A sample of the wire is first carefully cleaned (about one or two inches is sufficient) and weighed; it is then placed in a piece of hard combustion (glass) tubing, and a good current of pure and perfectly dry hydrogen is passed for a few minutes before heating, so as to ensure the expulsion of all the air from the apparatus, *otherwise an explosion may occur*. A Bunsen's burner may be applied for heating the wire, or, if a longer length of wire be used, Hoffman's gas combustion furnace is required. The loss of weight will represent the amount of zinc present, approximately. The wire should be allowed to cool in a current of the same gas, so as to avoid oxidising the iron. If the iron wire was oxidised before galvanising, the oxide would be reduced, and the loss of oxygen would consequently be reckoned as zinc. It would be advisable to keep a few fragments of platinum in the hydrogen generator, so as to keep up a full supply of gas, or an explosion might result.

The following arrangement should be used (see fig. 1). A is

FIG 1



a two-necked bottle for generating the hydrogen; ordinary zinc and diluted sulphuric acid (1 acid to 3 water) may be used. The platinum should be wrapped around the end of the funnel tube, so as to avoid its being lost.

B contains distilled water, so as to free the gas from acid, which may be carried over with it. C is a drying arrangement, which may contain fused chloride of calcium, or pumice-stone moistened with strong sulphuric acid. D is the tube containing the wire. Heat may be obtained from a large Bunsen's burner.

Mercury in Amalgams.—The same apparatus may be employed for ascertaining the amount of mercury in amalgamated zinc, &c., as, however the zinc volatilizes, carbonic acid is more convenient than hydrogen, since the zinc is thereby oxidized and prevented from condensing in the receiver with the mercury. For very accurate results the receiver may contain a little gold-leaf, so as to ensure the condensation of every trace of mercury. The mercury in this case is weighed direct, and the weight of the other metals may be obtained by difference. If much arsenic be present, it may be arrested from entering the condenser with the mercury by plugging up the end of the cumbustion tube nearer the condenser with a little galvanoplastic copper foil.

In some cases it may be more convenient, especially for substances in powder, to place the same in a small porcelain boat, which can easily be drawn into the tube, or a reduction tube with a bulb may be employed. The exit tube of the combustion tube D should have a little piece of rubber tubing drawn over it, so that it can be closed with a pinchcock if required. For greater accuracy, amalgams containing zinc or other volatile metals should be heated in a combustion tube closed at one end, and the mercury received in a condenser under water. A second distillation will yield the mercury almost free from zinc. If gold leaf be employed for condensing the mercury, it need not be thrown aside; the mercury can be easily expelled, which will leave the gold leaf ready for another operation. An ordinary chloride of calcium tube answers well for this purpose, as the mercury can be expelled again after weighing, and the weight of the mercury determined from the loss.

Estimation of Iron in Spelter.—I notice in looking over these papers that I have omitted to describe the method and apparatus for preparing the standard ferrous solution; but, as the same arrangement is required for this purpose, its description will be given in this place. The only difference to be pointed out is that, instead of spelter, we use soft clean iron wire for preparing the standard solution for titrating the permanganate solution. The dissolving of the spelter and the iron require exactly the same precautions, and the details are in every respect the same.

A weighed quantity of the spelter is placed in a marked 250 c.c. flask, and a small quantity of carbonate soda added, dilute sulphuric acid is poured in, and the apparatus put together as shewn in the figure.

A is a marked flask containing the spelter, &c., and connected with a bent delivery tube to another flask B, containing about 300 c.c. of distilled water, recently boiled so as to expel the atmospheric air. A pinchcock is placed between the two flasks, and it is also, I think, as well to have an exit tube to B supplied with a similar arrangement, so as to prevent any possibility of air entering B. The general way of fitting up the apparatus for this purpose leads me to believe that chemists overlook the fact that water becomes rapidly aerated from exposure to the atmosphere. Anyone who has been in the habit of drinking condensed water, as is the case at sea, must have noticed the difference between the mawkish flatness of the water when received from the condenser and the pleasant flavour it receives from only a few hours' exposure to the air, especially if passed through an ordinary filter (sand, &c.), by which it becomes more easily impregnated with air.

As the zinc dissolves the hydrogen passes through the flask B, and from thence through the exit tube into the air. As soon as the zinc has completely dissolved, the heat is removed, the water in the flask B then rushes into A, the pinchcock between A and B is closed, and also the pinchcock on the exit tube on B. The whole is allowed to cool to about 60° F., without any air being admitted. When cooled the water from B is poured into A until it exactly reaches the mark, the flask is corked, and its contents well shaken up.

The liquid from A is to be taken out by means of a marked pipette, and so to be transferred without being mixed with air, which could not be avoided by pouring out. The pipette should contain 50 c.c., and should be exactly 1-5th the capacity of the flask to the mark. The pipette is carefully dipped into the flask until the surface of the liquid is exactly even with the mark, the thumb is pressed on the top of the pipette so as to close it, and the pipette with its contents carefully withdrawn, and emptied into a perfectly white glass beaker standing on a white earthenware or porcelain tile. A 10 c.c. burette, divided into tenths, is filled with the permanganate solution, which is slowly delivered until the last drop added, gives a persistent reddish tint. The number of c.c. and $\frac{\text{c.c.}}{10}$ are read off, another 50 c.c. is added to the same beaker, and again titrated with the permanganate solution, the quantity of permanganate used is again read off, and if the results agree to $\frac{1}{10}$ c.c., another trial is made with a fresh quantity in *another beaker*. With care the exact quantity of permanganate solution required for the ending of the test is found, this multiplied by 5 will agree with the permanganate required for the iron contained in the total weight of the spelter.

Having determined in this way, using a weighed quantity of soft iron wire, the permanganate solution corresponding to a known weight of iron, we can easily find by a simple proportion the weight of iron contained in the quantity of spelter under test.

With a little practice, it is easy to estimate iron in spelter to within the limits of possible error not exceeding ·001 per cent.

Separation of Zinc from Manganese.—In the Leclanché element, when worked for a short time, manganese and zinc salts are formed, and it may be necessary for the electrician to know how to separate these metals or their salts.

In this cell the solutions tend to reduce the binoxide to a lower state of oxidation, which, consequently, being salifiable, will be found in the solutions.

The contents of the porous cell are well washed on a filter with warm distilled water until anything ceases to be removed.

The liquid should be concentrated, if very dilute, and boiled for a short time with a little acetate of soda, by which the iron, which is always present, will be precipitated as a basic salt (acetate). The filtrate may be rendered acid by the addition of a little acetic acid, and a current of sulphuretted hydrogen passed through it. The zinc will be precipitated as sulphide, whilst the manganese will remain in solution.

The manganese is separated by adding sulphide of ammonium

* Fresenius Qual. Analysis, fol. 447.

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to the neutral or ammonical solution, boiling for a few minutes, and allow to settle, filter and wash with water, to which sulphide of ammonium is added. The dried sulphide is heated, with the filter ash, in a Rose's crucible, as for zinc, copper, &c.

The contents of the porous pots in a Leclanché battery should not be thrown away; they still contain a large quantity of binoxide, and may be useful for the production of chlorine, &c.

The amount of carbon in a mixture of carbon and binoxide may be determined by reducing a portion of the mixture to powder, and heating a weighed quantity in a combustion tube open at both ends, whilst a current of dry oxygen is passed over it, collecting the carbonic acid in a weighed potash bulb apparatus containing caustic potash in solution.

If the manganese contain carbonates, the quantity should be ascertained by decomposing a weighed quantity of the mixture in an ordinary carbonic acid apparatus with *cold* hydrochloric acid.

The quality of the carbon may be ascertained by picking out as much as possible from the sample, and burning a small quantity of it on a piece of platinum foil. The residuum should be insignificant if graphite or gas carbon is used.

It should sink in water.

Wood charcoal is much lighter, and will yield a larger residuum when burnt.

The amount of ammonia contained in the solutions may be obtained by boiling the liquid in a flask with some caustic soda, and receiving the ammonia which is liberated in another flask containing a little hydrochloric acid. Evaporate the contents of the receiver to complete dryness, and weigh the residuum, which is chloride of ammonium.

Bichromate of Potash, or Anthydrochromate Potassium.—This salt is used in a form of battery which now occupies a prominent position in telegraphy. The pure salt is obtained for chemical purposes by repeated crystallisation of the commercial salt. A solution of the salt acidified with a little nitric acid should cause no cloudiness when nitrate silver is added, which, if chlorine or chloride of potassium were present, would happen.

In the commercial article it is never absent. Whether the presence of large quantities of chloride potassium influences the action of the battery is a point which any electrician who is using it ought to determine.

The quantity of chlorine may be determined by acidifying the solution rather strongly with nitric acid, and precipitating with nitrate silver. The chloride of silver well washed, dried, and heated to fusion, is weighed. The filter is burnt, the adhering chloride is converted into metallic silver. A little dilute nitric acid is poured on to the ash so as to oxidise the silver, and the solution boiled to dryness with an excess of hydroch'oric acid. A porcelain crucible must be used for this. The removal of the chloride from these crucibles is effected by adding a little hydrochloric acid and some pieces of metallic zinc.

The amount of pure salt present in a sample might be determined by the volumetric process employed for lead, the process being simply inverted. Unfortunately, however, if chlorine be present a slight error may arise, since the lead would be converted into chloride as well as chromate. If much chloride is present the sample will be found to have a very much larger quantity of water than the pure salt, and may, in fact, be even damp.

Separation of Zinc from Copper.—In the examination of battery residues, it may sometimes be necessary to determine the amount of zinc and copper present. It may be useful for electricians to know, that the sulphate of zinc met with principally in commerce is obtained from battery residues, and I would suggest that, instead of throwing away the contents of a cell when cleaning batteries, to keep a tub for collecting the waste liquor.

A few scraps of zinc should be always kept in the liquid so as to remove any copper which may be present. By adopting this method the electrician need never purchase sulphate of zinc for his batteries. I can imagine that this hint may be very useful to those in charge of the batteries on foreign stations. The only trouble to be met with may arise from the dilute state of the liquid; to avoid this the clear liquid, well freed from copper, should be decanted into stoneware pans, and allowed to evaporate in the sun, and the crystals may be collected and dried on canvas, or drained in a fine horse-hair sieve.

When the accumulation of this salt takes place faster than it can be used, cable companies and others would find that it may be converted into a source of profit.

The mud from batteries, which is reduced copper, may also be made a profitable article. Reduced copper in the cells, again, can always be returned to the copper works for working up. The mud may be easily reconverted into sulphate of copper by well washing with water, and drying the sediment on a cloth in a current of warm air. In this way it is rapidly converted into cupric oxide, and, if dissolved in pure sulphuric acid, will yield pure sulphate of copper.

To estimate the amount of copper in a battery residue, add a few drops of nitric acid to make sure that the solution contains no substance capable of reducing the copper when the liquid is heated, &c. Evaporate to dryness so as to expel every trace of nitric acid, supersaturate with ammonia to separate the iron, acidify the filtrate with hydrochlorine and titrate with stannous chloride.

To estimate the zinc, the following plan answers very well:—Add to the liquid rendered neutral, if acid, a tolerably large quantity of a cool solution of hyposulphite of soda. The hyposulphite of zinc, being soluble in an excess of this solution, can be removed. Hyposulphite of zinc, even in presence of a large quantity of hyposulphite soda, is decomposed when boiled. It is, therefore, best to allow the mixture to stand in a warm place until the copper has entirely deposited as sulphide. If the hyposulphite method be used for separating copper from zinc, the liquid should be filtered, and the filtrate again tested with a fresh quantity of hyposulphite, again filtered, and the process repeated. It does not appear possible to separate the copper entirely by this method. The heating and filtering should be repeated until sulphide of ammonium added to the filtrate yields a dirty white precipitate, inclining to black. The quantity of copper still remaining with the zinc is then very small. The filtrate is treated with ammonium sulphide, and the dried precipitate and filter ash heated in a Rose's crucible, as mentioned before.

The separation of these metals by means of sulphuretted hydrogen requires great precaution to be taken as the two metals are precipitated together.

For great accuracy sulphuretted hydrogen must be used.

The two metals, in the form of sulphides, may, according to Professor Hoffman, be completely separated by treating the precipitate with dilute sulphuric acid and heating; the zinc is dissolved out, leaving the copper as sulphide, unaffected.

Separation of Copper from Nickel and Zinc.—German silver. Dissolve the alloy in nitric acid, dilute with water, and pass sulphuretted hydrogen until the copper is entirely precipitated; a little zinc sulphide will be co-precipitated with the copper, but is, to a great extent, redissolved on boiling. When slightly cooled, again pass the sulphuretted hydrogen for a short time, when the precipitate will be found almost free from zinc. The filtrate will contain zinc and nickel.

FRICTIONAL ELECTRICITY.—PECULIAR PHENOMENA.

One of our correspondents, in an early number, described his experiences, during frosty weather, of personal electrical phenomena, and, as several letters have appeared recently in *The Times* and elsewhere on the subject, it may be interesting to our readers to see the following abstract of a paper by Prof. Loomis, in the report of the twenty-seventh meeting of the British Association (1857). This paper contains an account of curious and interesting phenomena. The paper is under the title, "On Certain Electrical Phenomena in the United States," and reads thus:—"Atmospheric electricity is very abundant in the United States, and often exhibits phenomena more remarkable than are witnessed in most countries of Europe, especially in England and Germany. These phenomena are not confined to any particular season of the year, but the exhibitions in summer appear under a different form from those of winter. In summer free electricity exhibits itself chiefly in the form of lightning during thunderstorms, and these exhibitions are often among the most sublime and impressive phenomena witnessed in any part of the globe. The telegraph wires are exceedingly sensitive to the approach of a thunderstorm. The wires are often charged with electricity from the effects of a storm so distant that no thunder is heard or lightning seen. I have often stood at such times in a telegraph office, and introduced my own body into the electric circuit, by taking hold of the telegraph wire with one hand, and with the other grasping a wire which communicated with the earth. A frequent twinge is felt in the arms, and sometimes through the breast. The shock is pungent and painful, even when scarcely the slightest spark can be obtained by bringing the two wires nearly in contact. Such experiments are unsafe when the electric cloud is near. If, during the passage of a thunder shower, the telegraph apparatus is left in communication with the long telegraph wires, the fine wires of the electro-magnets are almost sure to be melted, and the magnets thereby rendered useless. Sometimes, in telegraph offices, there occurs an explosion, which melts large wires, and is dangerous to human life. The effect of a feeble current of atmospheric electricity on the telegraph wires is the same as a current from a galvanic battery. It makes a dot on the telegraph register, and when a thunderstorm passes in the neighbourhood of a telegraph line those dots are of constant occurrence, and being interposed between the dots of the tele-

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graph operators, they render the writing confused and often illegible. The operators are, therefore, commonly compelled to abandon their work when a thunder shower prevails in the vicinity of any part of the line. [Such difficulties as these have now been overcome to a considerable extent.—Ed. *El.*] The aurora borealis is very common in the United States even in summer, but on account of the long continued twilight it is seldom witnessed with such brilliancy in summer as in winter. During winter thunderstorms in the United States are of very rare occurrence, but even at this season they are not entirely unknown. Sometimes in midwinter, after a series of unusually warm days, a strong wind suddenly springs up from the west, attended by a shower, during which several flashes of lightning, accompanied by thunder, are noticed. Such a shower is invariably followed by a great and sudden fall of the thermometer. But, while electrical discharges in the form of lightning are rarely witnessed in winter, other electrical phenomena of great interest are of almost daily occurrence. Those phenomena consist of free electricity residing upon almost all bodies resting on the earth, but sufficiently insulated. This free electricity is particularly noticeable on the clothes and hair of the human body. During the cold months of winter, the human hair is commonly electrical, and especially when it is brushed with a fine comb. Often at such times the fine hairs are seen to stand erect, and the more you comb to make them smooth the more obstinately they refuse to keep their proper place. If you present your fingers to those electrified hairs, they fly to meet you, like a lock of dry hair attached to the prime conductor of an electric machine. In such cases there is but one remedy; the hair must be thoroughly moistened, after which it lies quietly in its place. During the same season of the year all woollen articles of clothing become highly charged with free electricity. The pantaloons, in particular, are found to attract light floating particles of dust, down, &c., especially near the feet, and it is impossible to cleanse them by brushing. The longer you brush the more your clothes are covered with dust and lint. Nothing less than a wet sponge is efficient to cleanse them. At night, when you take off your pantaloons, you hear a distinct crackling noise, and in a dark room perceive a succession of flashes. You draw your fingers down over them, especially near the lower extremities, and you perceive a repetition of the crackling noise, accompanied by distinct flashes of light. As you take off your flannel drawers the crackling is again heard, louder than before, and the flashes of light are more vivid. If you take a woollen blanket from your bed, hold it suspended in your left hand, and draw the fingers of your right hand over it, the crackling is equally loud and long continued. Your fingers seem enveloped in a blaze of light, and the flashes can be several times renewed. Brute animals do not escape the general electrical influence. In a cold frosty night, you draw your hand gently over a cat's back, and you hear a distinct crackling noise, while the cat shows unmistakeable signs of bad temper, and refuses her consent to play the philosopher with you. Persons riding on horseback during a snowstorm in the night have frequently noticed the extremities of their horse's ears tipped with light, like that of a pale, steady flame. The preceding phenomena are either unknown in summer, or are only noticed occasionally, and in an inferior degree; but the aurora borealis is often witnessed in the United States during winter, and frequently attains a splendour such as is surpassed in but few portions of the globe. During the severity of winter, and especially in houses which are furnished with heavy carpets and kept thoroughly warmed, even more remarkable electrical phenomena are often witnessed. If you walk across such a carpet with a slight shuffling motion, and then present your knuckles to some metallic object, as the knob of a door, you perceive a decided spark and a faint snap. By walking rapidly two or three times back and forth the spark may be increased, and becomes, perhaps, a quarter of an inch or more in length, and has great intensity, accompanied by a smart snap. This phenomenon is not peculiar to any particular house or style of carpet, but in the cold months can be witnessed in almost every house in New York where there is a thick woollen carpet and the room is kept habitually well-heated and dry. In some houses these phenomena are so remarkable that persons who have never witnessed them have listened to the accounts with evident incredulity. A few winters ago I received from a female friend an account of some phenomena which she had witnessed at the house of Mrs. C., in New York, and which appeared so remarkable that I concluded the account must be greatly exaggerated. I was induced to call on Mrs. C., and request her to favour me with an exhibition of her electrical powers, to which request she readily acceded. We mere sitting in a parlour covered with a heavy velvet carpet, and lighted with gas by a chandelier suspended from the ceiling. Mrs. C. rose from her chair, advanced one or two short steps, and gave a slight spring towards the chandelier, which was above her reach when her feet rested upon the floor. As her finger approached the metal I perceived a brilliant spark, and heard a snap such as would have attracted the attention of a person casually walking through the hall, separated from the parlour by a closed door. The spark was more brilliant than that which is furnished by an ordinary electrophorus when most highly excited, but its length was not so great. A few steps upon the carpet were sufficient to renew the electric charge, and the spark was perceived whenever Mrs. C. touched a metallic object, like the knob of a door or the gilded frame of a mirror. The facts which had been before recited to me now no longer appeared incredible, and most of them I verified by my own observations. On approaching the speaking tube to give orders to the servants, Mrs. C. repeatedly received a very unpleasant shock in the mouth, and was very much annoyed by the electricity until she learned first to touch the tube with her finger. In passing from one parlour to the other, if she chanced to step upon the brass plate which served as a slide for the folding doors, she received an unpleasant shock in the foot. A visitor upon entering the house, in attempting to shake hands with Mrs. C., received a shock which was quite noticeable, and somewhat unpleasant. A lady on attempting to kiss her was saluted by a spark from her lips. Her little girl on taking hold of the knob of a door received so severe a shock that she ran off in great fright. Larger children frequently amused themselves by shuffling about on the carpet, and giving each other sparks from their fingers. The preceding is the most remarkable case I have myself witnessed, but I have heard of several other houses in New York which appeared about equally electrical; and most of these phenomena have become so familiar in New York that they have ceased to excite surprise. The electricity thus developed exhibits the usual phenomena of attraction and repulsion, and is capable of igniting combustible bodies. By skipping a few times across the room with a shuffling motion, and, then presenting the knuckle to an open gas-burner, the gas may be ignited. This experiment generally fails unless the burner be warm; but if, after a jet has been some time burning, you extinguish the flame and then draw a spark with your knuckle from the warm burner, the gas is readily ignited. After a careful examination of several cases of this kind, I have come to the conclusion that the electricity is excited by the friction of the shoes of the inmates upon the carpets of the house. I have found, by direct experiment, that electricity is developed by the friction of leather upon woollen cloth. For this purpose I stood upon an insulating stool, and, spreading a small piece of carpeting upon a table before me, rubbed a piece of leather vigorously upon it, and then, bringing the leather near the cap of a gold-leaf electrometer, found that the leaves were repelled with great violence. The electricity of the leather was of the resinous kind. Electricity must, therefore, necessarily be excited whenever a person walks with a shuffling motion across a carpet, but it may be thought remarkable that the electricity should be intense enough to give a bright spark. In order to produce the highest effect there must be a combination of several favourable circumstances. The carpet, or, at least, its upper surface, must be entirely of wool and of a close texture. From my own observations, I infer that heavy velvet carpets answer this purpose best. Two thicknesses of ingrain carpeting answer very well. A drugget spread upon an ingrain carpet yields a good supply of electricity. The effect of the increased thickness is obviously to improve the insulation of the carpet. The carpet must be quite dry, and also the floor of the rooms, so that the fluid may not be conveyed away as soon as it is excited. These conditions will not generally exist, except in winter, and in rooms which are habitually kept quite warm. The most remarkable cases which I have heard of in New York have been in close, well-built houses, kept very warm by furnaces. These furnaces are erected in the cellar, and are filled with anthracite coal, which is kept constantly burning from autumn till spring. The heated air is conveyed to the hall, the parlours, and to every room in the house, so far as is desired, through large flues built in the walls, the flues having a section of about one square foot. In such a house the wood during winter becomes very dry, and all the furniture shrinks and cracks. The electricity is most abundant in very cold weather. In warm weather only feeble signs of electricity are obtained. The rubber, viz., the shoe, must also be dry, like the carpet, and it must be rubbed upon the carpet somewhat vigorously. By skipping once or twice across a room with a shuffling motion of the feet, a person becomes highly charged, and then, upon bringing the knuckle near to any metallic body, particularly if it have good communication with the earth, a bright spark passes. In almost any room which is furnished with a thick woollen carpet, and is kept tolerably warm and dry, a spark may thus be obtained in winter; but in some rooms the insulation is so good that it is impossible to walk across the floor without exciting sufficient electricity to give a spark.

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THE DIFFICULTIES IN THE WAY OF INTRODUCING IMPROVEMENTS.

We have long desired to direct attention to a phase of negative work which it is very difficult to understand. Most of us are brought into contact from time to time with men of great ability in their own sphere who are supposed to have no other wish than to see the adoption of some particular "hobby." Frequently the introduction of this particular thing would be of very great advantage to the community at large, but, perhaps, there is no advantage touching any one section directly, and therefore making it worth the while of that section to carry the work into practice. At other times, it is found to be impossible to move the inertia of a Conservative professional opinion. "We have," say the members of the profession, "managed very well hitherto with the old appliances, and though, perhaps, your new-fangled notions may have something in them, we do not care to commence our schooling again," and so it is found impossible to move an inch. We will presently refer to one or two examples of this *nonchalance*, in cases where the disadvantages are seen and are immediate. At a late meeting of the Society of Telegraph Engineers, the subject for discussion was that of Cable Grappling, brought forward by Mr. Jamieson. The chairman of the evening (Mr. W. H. Preece), in his speech at the conclusion of the discussion, made some of the happiest suggestions and most pertinent remarks in one or two directions which we ever remember to have heard. If it was compatible with the arrangements of the society, we would suggest to them that the sentences then casually spoken should form the subject of an evening's discussion, and, if the influence of the society could move the Government to act, great good would be accomplished. We refer to the verification of charts, and the continued exploration of the configuration of the sea-bed. Mr. Preece remarked that it was a disgrace to the greatest maritime nation in the world that its charts should be incorrect. We quite agree with him. By fits and starts—shamed into it almost by the action of America, by the intelligence of the United States Naval Department, and, we must not forget to add, by the late Captain Sherard Osborn and those who acted with him—our Government has from time to time, in a more or less desultory manner, sent out expeditions with a view of "sounding the sea." One of the most conspicuous of these was the Challenger expedition, an expedition which has been highly praised in some quarters and severely criticised in others. There is no doubt, however, but that in almost every case the very worst method for obtaining good results was taken, and, with a few exceptions, the results obtained, good, bad, or indifferent, cannot be utilized by the public, for the public knows little or nothing of them. We shall speak of one of the failures of the Challenger expedition which concerns our present subject, the introduction of improvements. In submarine cable work it is of the utmost importance that the configuration of the sea-bed should be accurately known, and one would naturally think that an expedition sent out by the Government would be supplied with the very best and latest appliances for sounding. The Government is in no way to blame that this was not the case; the fault lies at the door of the advisers who, thinking they knew everything, acted but to show their ignorance. Prof. Alex. Agassiz, in describing an American Expedition, thus spoke of the Challenger Expedition:—"Marked improvements have been effected in deep-sea dredging and work of like character, so that much more can be done in a given time than formerly, and the results are more satisfactory. In sinking the lead to great depths heavy weights are required. On the Challenger the mode of ascertaining that the lead touched bottom was by noticing when the rope ran out more slowly than before. This operation was performed with a very heavy rope, such strength being necessary to hold the weights employed in sinking it. It was liable to an error of, perhaps, 300 fathoms in giving great depths. It is strange that the English did not use the invention of their own countryman, Sir William Thomson, instead of the antiquated sounding-rope. The improvement principally consists in substituting a piano wire. This, after running out, leaves the shot with which it is weighted on the bottom. Repeated soundings with the piano wire on board the Blake indicated that the accuracy attained was within 1-100 of 1 per cent.; the Challenger soundings were only within 5 per cent. The Thomson sounding-wire was unfavourably reported upon by the British Commission that had the outfit of the Challenger in charge. In this country it was favourably received

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and tried in the sounding expeditions of the Tuscarora, and, under the skilful management of Commander Belknap, who added to its usefulness by various devices, it met great success. Since its introduction here, the piano wire has been altogether used by American hydrographers. The time gained by using the wire is quite remarkable; for instance, twenty to twenty-five minutes, as compared with two hours. The iron shot weight left on the bottom of the ocean is, perhaps, a sixth of that lost by the old process." In his paper on Cable Grappling, Mr. Jamieson spoke very highly of Professor Thomson's system of sounding; but the years pass on, the old methods are constantly used, time is wasted, and the improvement is far from being generally adopted.

To take another and, perhaps, a still more important illustration, we may refer to the terrible, and yet preventible, losses of life and property sustained by collisions at sea. Unfortunately, of late, such collisions have been painfully prominent. We have frequently heard seamen state that one great want was some means of ascertaining the exact movements of the helm of a ship in their immediate vicinity. The Francis lamp and apparatus has been specially devised to do this. Mr. Francis recommends the use of three lights instead of two. He would give us a white, red, or green light, according to the position of the helm. His arrangement is exceedingly simple, and may be briefly described. With the ordinary white lens he combines two others, red and green. The red and green lenses are accurately counterbalanced, so that when the helm is amidship neither the one nor the other interferes with the white light. When, however, the helm is put to port, or in the opposite direction, an electrical contact is made, and this brings into play a small electro-magnet, which attracts the iron holder of the red or green lens which forms the armature of the particular magnet brought into play. This attraction brings down the particular lens in front of the light, and there it remains, and must remain, so long as the helm is on that particular tack. Wherever a light can be seen, the exact movements of the helm can be made known, and if these movements were known with certainty collisions would be of much rarer occurrence than they are now. This lamp, like Sir William Thomson's sounding apparatus, is not a thing of yesterday; it is some years old, yet, day by day, ships leave port without availing themselves of such a simple means of preventing accidents. Surely, as Mr. Preece says, a maritime nation like England ought not to allow the stigma of carelessness in relation to nautical matters to rest upon it. "Let us alone," say the owners; "why saddle us with another 20*l.* per ship; collisions will, in the nature of things, occur; they always have occurred, and they must occur; you mean additional expense, and less profits, but we question the additional safety. We will think of it, *after* this voyage." So the old way is continued, excuse after excuse is found, till one day comes the sad tidings of a vessel being lost. The owners congratulate themselves on being insured. They are very sorry, the ship was well found, it had gone safely through a hundred voyages; but all this does not replace the sailors lost, or bring comfort to the lone ones left behind, solely through the neglect to "introduce improvement."

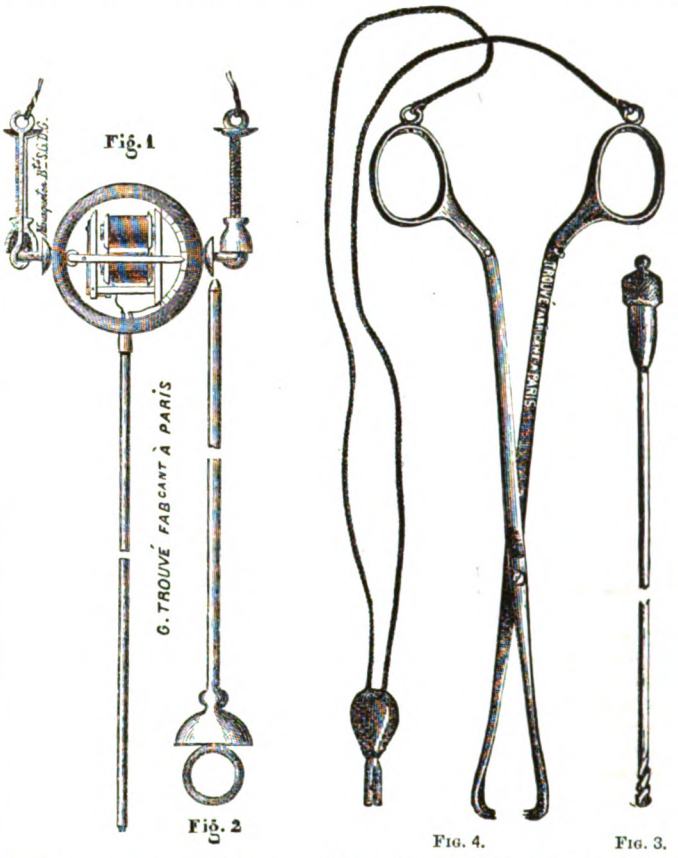
TROUVE'S ELECTRIC EXPLORER (FOR WOUNDS) AND BULLET EXTRACTOR.

These beautifully-constructed surgical instruments were noticed in our issue of October 5; and the interest taken in them by certain of our readers now induces us to give illustrations of them.

The Revealing Apparatus, which is represented in its actual dimensions by Fig. 1, resembles a very small watch enclosed within two transparent glasses. It contains a minute electro-magnet, arranged to work a vibrating armature, so constructed as to resist any shock. Externally, two small rings serve to connect it with the terminals of one cell of the Trouvé reversal cell, or any other convenient electromotor. The apparatus is completed by a stylet which is readily fitted to that part of the instrument already described, and which is formed of two wires well insulated from each other, enclosed in a protecting tube, and tipped with sharp points which project a few millimetres beyond the casing. These two wires form portions of the circuit of the battery and electro-magnet, so that, if a conductor be brought into contact with the points, the circuit will be completed, and the current will cause the armature to vibrate.

The Exploring Probe (Fig. 2) is a rigid or flexible canula which serves for the preliminary exploration of the wound, and facilitates the introduction of the exploring apparatus next to be mentioned.

The mode of using the apparatus is as follows:—The exploring probe is first introduced within the wound. A blunt mandrel, moving freely within the canula, and protected from the pressure of the tissues, allows of the sense of touch being exercised to greater advantage than it could be with the canula alone. When contact is made with a foreign solid body within



the tissues, some slight blows given with the end of the mandrel may often suffice to indicate the presence of a metal, in which case the greater part of the work is done. But it often happens that the projectile is enveloped in tissues, or by pieces of fabric which have been carried away, and in this case the second operation becomes necessary. This consists in introducing within the canula, in place of the blunt mandrel, the stylet, which is connected with the revealing apparatus. The two points of the stylet penetrate the envelope of the projectile; and, if this be of metal, the circuit is completed, and the armature may be seen, heard, or felt to vibrate.

The next thing is to ascertain the nature of the metal; and, in the battle field, this can hardly be other than lead, brass or gun-metal, or iron.

If it be lead, and the stylet be moved to and fro laterally, the two points, penetrating the metal, will close the circuit in any position.

The case is different with iron or brass. When the points of the stylet are in contact with either of these metals, a slight inclination of the apparatus suffices instantly to break the circuit, and the armature ceases to vibrate.

In order to distinguish between iron and any copper alloy, a small magnetic needle is brought into proximity with the wound.

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If it remains wholly unaffected, the metallic body is probably brass or bronze.

When the wound has closed up, the exploration is commenced by taking the pain as a guiding indication; afterwards, two long acupuncture needles are passed through the tissues, and, replacing the joints of the stylet, are brought into metallic contact by the projectile—forgotten, perhaps, for years, in the body of the patient.

Should the revealing apparatus remain mute, the solid body is probably a splinter of bone, or a piece of wood or stone. Before operating its extraction, it is often of interest to determine its nature. With this view, M. Trouvé has provided a small double screw (Fig. 3), by the rotation of which minute portions of the substance, sufficient to give an indication to the surgeon, may be obtained whenever this substance is of a friable nature. Should the screw not penetrate, nor retain any fragment in the interior portion of the threads, the substance is probably silica.

In many cases the double screw may serve for the extraction of the projectile; in the case of lead, for instance, it is made to penetrate like a corkscrew in a cork.

But, if the screw cannot penetrate, the elongated pincers (Fig. 4), of which the two blades are insulated from each other, and connected with the revolving apparatus by means of flexible conductors, should be employed. With this apparatus, one may be certain that the object seized is metallic, there is no danger of seizing a neighbouring organ, such as a bone; and, if the projectile be held by the pincers, together with a muscle or any other portion of the body, one is warned of the fact. In a word, any mistake becomes impossible.

The Faculty of Medicine of Paris showed its appreciation of these instruments, and of the methods of operating in which they are employed, by awarding to the inventor the Barbier prize.

GALVANOMETERS.—IV.

By J. T. Sprague, M.S.T.E.

(concluded from page 280, vol. I.)

Tangent Galvanometers.—As the measurement of the deflective power of the current is obtained in terms of the resistance exerted by the earth's magnetic field, this latter must be expressed in a definite value, or unit, in order to obtain the value of the current. The earth being a magnet, its lines of force converging towards the magnetic poles, of course the intensity of its magnetism is, as with small magnets, greatest at these poles; but this magnetism has two actions on our instruments; one, which is measured as the *vertical* intensity, tending to draw the relative poles together, that is, to cause a bar magnet to place itself vertically at the magnetic pole, and to cause it to "dip" proportionally to the degrees of magnetic latitude; this increases as the pole is approached. The other action, that which is used in compasses and galvanometers, moves the needle in a horizontal plane, drawing it to the magnetic N. and S. meridian, or zero line, and would draw a single pole (were such a thing possible) along that line, is called the horizontal intensity, and is usually written as H in formulæ. This is necessarily strongest at the magnetic equator, where the natural position of the needle, or the resultant of the earth's force, is horizontal, and reduces in energy as the pole is approached, where the horizontal motion is absorbed in the vertical. The horizontal intensity is proportional to the squares of the rates of oscillation of the needle at different places, but, for full information on this subject, works treating of magnetism can be consulted. What is necessary to observe here is that any galvanometer whose constant, or current value is measured at one place, will require a correction when used at other places proportional to the relative horizontal intensities of the two places. This value is subject to small changes (besides the irregular ones occurring during magnetic storms), but the value usually employed is that measured in 1865; expressed in the metre gramme absolute units that value is 1·764; in the foot-grain system its value is 3·826. These are the values symbolized by H, and they mean that a free single pole of these weights would, under the earths magnetic influence, acquire those velocities in one second of time.

But the zero N. and S. line is itself not fixed, so that to make correct measurements, the galvanometer needs to be placed in the actual zero line at the time of observation. There is a small annual variation of the mean position dependent on the season, and a larger daily one, both, therefore, due to the changing position of the sun in relation to the place of observation, and probably electro-magnetic in character, and caused by thermo-electric currents set up by the motion of the earth under the sun. According to observations made in Paris by Cassini, the amplitude of these diurnal motions is 13 to 15 minutes of arc, from April to September, and from 8 to 10 from October to March. During the night the needle is nearly at rest; at sunrise the north pole moves westerly to a maximum between noon and 3 p.m., when it returns to the east in both cases as though the south pole were attracted towards the sun; these variations increase as the magnetic latitude increases. The needle occupies the mean zero position about 10 a.m. and 7 p.m.

The tangent galvanometer can be constructed in many various forms if the true principles are kept in view. Fig. 1 I take from

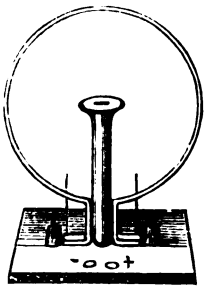

FIG. 1

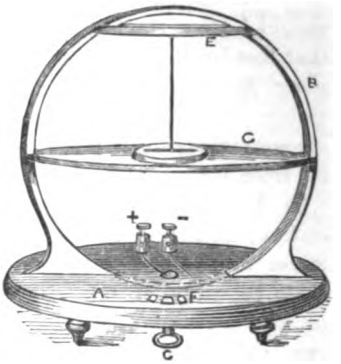

FIG. 2

a well-known work, chiefly as an illustration how it should *not* be made, and because it shows several common errors of construction. By placing the two connections at some distance apart in the plane of the wire, it is evident that the part of the circle shown by vertical dotted lines is partially neutralised by the wires below, leading to the conductors; the conductors themselves also will act irregularly on the needle, according to the side to which it is deflected, and, at any rate, destroy the true tangential values of the deflections. It must always be remembered that conducting wires and connections form an integral part of every electric system; we cannot confine the action just to those wires which we call the instrument proper. In the figure the wire ought to be brought close to complete the circle; the stand being so constructed as not to interfere with it, and the connecting rods brought out at right angles to the plane of the circle, as close together as possible, and led to binding screws, also close together, in front of the instrument, as shown in the circles + and —.

In good instruments the wire circle and dial are often made moveable upon the stand, for two reasons; first, to enable the zero adjustment to be easily made; and secondly, in order to convert the instrument at will into a sine galvanometer. Such is the form described in many books as Pouillet's galvanometer. This, however, adds a good deal to the complication of making, and there is a much better mode of attaining the same results. This is to construct a separate stand available for a variety of purposes. This may be constructed in wood or in metal; a lower disc or frame of circular form is fitted with three levelling screw feet, and carries a point in its centre; a similar disc, or one a little smaller with bevelled edge, carrying a cup in its centre, floats upon the point which is to be just high enough to take the weight without raising this disc from the lower one, so as to allow it to "wobble." If upon one of these edges is marked a zero line, or a vernier system, while the other is divided into degrees of arc, we have an easily constructed and most useful appliance, by which any galvanometer can be used on the sine principle.

The best construction I have been able to devise is shown in Fig. 2. An elliptical board A is supported by three levelling screws, two visible and one beyond the binding screws. The ring of wire, of which I shall speak presently, is let into this table, and supported by two blocks of wood; across its middle (a little below the centre, of course) a table C is secured which carries in its middle the dial D, surrounded by a rim in which a glass cover can be placed. The needle may be supported by a steel point in the centre of the dial, or (which is far better) suspended by a silk fibre from the middle of the small piece of wood or brass E, also secured to the ring; this can be best adjusted to centrality, so as to compensate for any slight want of true levelling, by an apparatus similar to the mechanical stage of a microscope, or by one of the same character which I have designed, as easy of construction, and shown, full size, in Fig. 3. I have shown an instrument of three circuits, thrown into action by a commutator working under the stand. The end of the first circuit, *i.e.*, the stoutest conductor is soldered to binding screw—, the other ends are taken to three studs shown, the wires being slightly let into the wood; a screw-stud connected itself to binding screw + carries a spring with handle G, which thus completes either circuit as needed; all these wires should be kept as close as possible, so that practically they neutralise each other's influence on the needle.

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Such a three-circuit instrument may be constructed by forming a ring of the desired size, by means of a hoop, out of paper pasted up, which is best accomplished upon a disc of wood cut in two and temporarily secured to the table C; this can then be mounted on a stand for convenience of winding. Lay on forty-five turns of the finest wire to be used, say No. 20, then four of No. 16, then a complete circle of thickish copper sheet; next five turns of No. 16 and forty-five of No. 20 will complete the wires. The ends of these, coming out at the lowest point of the ring, must be so connected that the current enters by the single ring and goes to the 1 stud, or continues through the nine turns of No. 16, and then, in like manner, to stud 2 and to the ninety turns of No. 20, always, of course, in the same direction around the ring, and, finally, to 3 stud. In this way the commutator includes in the circuit one, ten, or 100 turns of wire, and by the arrangement of winding, these being practically all at the same distance from the needle, their actions will be in that proportion, and one value will apply to all the circuits.

Fig. 3 consists of a brass plate D, which is secured upon the table E of Fig. 2. Upon it is mounted the screw F, which acts upon a set of teeth upon the edge of (or raised a little above) the plate C, which turns upon a screw which secures it to D, and so moves its central point, where there is a large hole, across the zero line or plane of the ring; this plate C in turn carries a plate B, which is in like manner moved by the tangent screw E, mounted on C. On this again is placed the rod A, to which the fibre carrying the needle is secured, and by which it can be raised or lowered.

The needle may be made of watch spring, or of several pieces, and fitted with a light wire indicator; aluminium would be best, if it could be obtained hard, as I think it can with a little silver

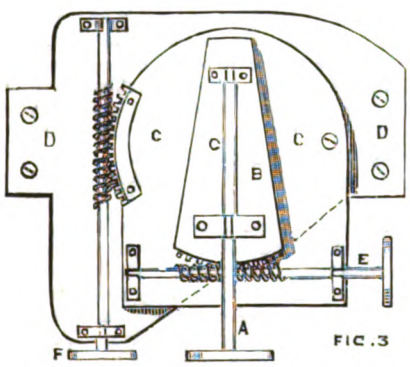

FIG. 3

FIG. 4

alloyed with it, but a fine German silver wire will answer. The objection to these indicators is their weight, and the consequent long swinging of the needles, but a little practice with the commutator G will overcome this, as it is easy to make and break circuit so as to lead the needle slowly up to the proper deflection with scarcely a return swing, or to meet the swings, and bring it to a dead stop. Some prefer to use a compound needle, by cementing a series of magnets to a circle of aluminium or mica; such a needle being less deranged in its polar positions in the field of the current. But whatever plan is used the needles should be formed as in A Fig. 4 of a long taper form. The current tends to disturb the needle's magnetism, and in a bar such as B Fig. 2 the N. and S. line would shift about between the dotted diagonal lines, thus rendering the readings incorrect. For this reason it is best to use needles constructed of thin steel, such as watch spring, in pairs, or more, and to place them vertically instead of horizontally.

The actual deflection any particular tangent galvanometer will produce with a given current, say the unit current of 1 veber, will depend directly upon the number turns, and inversely upon the distance of the rings of wire from the centre; this relation is deriveable from the following law:—

A current of unit strength placed once round the circumference of a circle of unit radius, in the plane of the magnetic meridian, will cause a short magnet suspended at the centre of the circle to be deflected through an angle whose tangent is 6·2832, *divided by the absolute horizontal intensity of the earth's magnetic force at the time and place of observation.*

For any diameter, calling the earth's horizontal intensity H=1·764, r the radius of the coil, d its diameter, L length of wire in the coil, all in metres, n the number of turns, θ the angle of deflection, and C the current strength in absolute (metre-gramme-second) units, we have:—

$$C = 1{\cdot}764 \frac{r^2}{L} \text{tang. } 6^\circ,$$

$$\text{or, } C = 0{\cdot}5615 \frac{d}{n} \text{tang. } \theta,$$

or the figure 3·826, with measures in feet, will give the current in the English foot grain system.

In order to obviate the small errors of the single ring system, when the ring is not very large, two rings are occasionally employed, in order that the needle, being suspended between them, the errors due to its motion may compensate each other. This, however, tends to introduce another error affecting the smaller deflection, and therefore of more consequence than the other, which tells mainly upon the comparatively useless large deflections. It is also stated that the deflections are accurate if the wire is wound upon a section of a cone, of which the needle forms the apex, at a distance of one-fourth of the diameter of the nearest coil of wire. In neither of these forms is there any defined law of construction, and the chief advantage of the double ring form is that the resistance may be lower by dividing the current, and the range of power regulated by the distance of the rings. It would seem that these forms are more expensive and difficult of construction than the simple ring, and that they have small advantage over it, if the ring itself is made of a width at least equal to the length of the needle and of sufficient diameter. Deflections exceeding 60° are very unreliable, because of the rapid growth of the tangential scale. Even at 50° a single degree means three times as much current as at 10°, four times at 60°, and forty times at 80°, so that the smallest error in reading becomes of great importance at these large angles.

An approximately correct tangential instrument can be constructed of a circular sheet of metal, about twice the diameter of the length of the needle, especially if a compound circular needle system is employed, as before described. An instrument of this type is used in America, provided with a system of flat coils, such as are employed in ordinary galvanometers, and the excess of action of the upper sides beyond the reverse action of the lower is availed of to produce the deflections. The influence of such a system upon the magnet is largely influenced by the distance at which the magnet is placed.

ON THE ILLUMINATION OF LINES OF MOLECULAR PRESSURE, AND THE TRAJECTORY OF MOLECULES.*

By William Crookes, F.R.S., V.P.C.S.

(concluded from p. 60.)

Projection of Molecular Shadows.

The author next proceeds to examine the phenomena of shadows cast by the green light. The best and sharpest shadows are cast by flat disks and not by narrow pointed poles; no green light whatever is seen in the shadow, however thin, or whatever substance be the material casting it.

From these and other experiments, fully described in the paper, the author ventures to advance the theory that the induction spark actually illuminates the lines of molecular pressure caused by the electrical excitement of the negative pole. The thickness of the dark space is the measure of the mean length of the path between successive collisions of the molecules. The extra velocity with which the molecules rebound from the excited negative pole keep back the more slowly moving molecules which are advancing towards the pole. The fight occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the collisions of the molecules.

When the exhaustion is sufficiently high for the mean length of path between successive collisions to be greater than the distance between the fly and the glass, the swiftly moving rebounding molecules spend their force, in part or in whole, on the sides of the vessel, and the production of light is the consequence of this sudden arrest of velocity. The light actually proceeds from the glass, and is caused by fluorescence or phosphorescence on its surface. No light is caused by a mica or quartz screen, and the more fluorescent the material the better the luminosity. The author considers that the greenish yellow light is caused by the direct impact of the molecules on the surface of the glass. The shadows are not optical, but are molecular shadows, only they are revealed by an ordinary illuminating effect. The sharpness of the shadow when projected from a wide pole proves them to be molecular.

Nature of the Green Phosphorescent Light.

The author adduces the following characteristics of the green phosphorescent light, distinguishing it from the ordinary light observed in vacuum tubes at lower exhaustions:—

a. The green focus cannot be seen in the space of the tube, but only where the projection causing it strikes the glass.

b. The position of the positive pole in the tube makes scarcely any difference to the direction and intensity of the lines of force which produce the green light. The positive pole may be placed

* Abstract of a Paper read before the Royal Society.

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in the tube either at the extremity opposite the negative pole, it may be below it, or by its side.

c. The spectrum of the green light is a continuous one, most of the red and the higher blue rays being absent; whilst the spectrum of the light observed in the tube at lower exhaustions is characteristic of the residual gas. No difference can be detected by spectrum examination in the green light, whether the gas whose residue it is has been nitrogen, hydrogen, or carbonic acid.

d. The green phosphorescence commences at a different exhaustion in different cases.

e. The viscosity of a gas is almost as persistent a characteristic of its individuality as its spectrum appearance. The author refers to a preliminary note and a diagram* of the variation of viscosity of air, hydrogen, and other gases at exhaustions between 240 M and ·1 M. From these and other unpublished results, the author finds that the viscosity of a gas suffers very little diminution between atmospheric pressure and an exhaustion at which the green phosphorescence can be detected. When, however, the spectral and other characteristics of the gas begin to disappear, the viscosity also commences to decline, and at an exhaustion at which the green phosphorescence is most brilliant, the viscosity has rapidly sunk to an insignificant amount.

f. The green phosphorescence will not turn a corner in the slightest degree, but radiates from the negative pole in straight lines, casting strong and sharply-defined shadows of anything which happens to be in its path. On the other hand, the ordinary luminous phenomena of vacuum tubes will pass along any amount of curves and angles.

Phosphorescence of Thin Films.

An experiment is next described in which a film of uranium glass, sufficiently thin to show colours of thin plates, is placed in front of a thick plate of the same glass; the whole being enclosed in a tube with terminals, and exhausted to a few millionths of an atmosphere. With this apparatus the following observations are recorded:—

a. The uranium film, being next to the negative pole, casts a strong shadow on the plate.

b. On making contact with the coil, the thin film flashes out suddenly all over its surface with a yellowish phosphorescence, which, however, instantly disappears. The uncovered part of the plate does not become phosphorescent quite suddenly, but the phosphorescence is permanent as long as the coil is kept at work.

c. With an excessively faint spark the film remains more luminous than the plate, but on making the spark more intense, the luminosity of the film sinks and that of the uncovered part of the plate increases.

d. If a single intense spark be suddenly sent through the tube, the film becomes very luminous whilst the plate remains dark.

These experiments are conclusive against the phosphorescence being caused by the radiation of phosphorogenic ultra-violet light from a thin layer of arrested molecules at the surface of the glass, for, were this the cause, the film could under no circumstances be superior to the plate.

The momentary phosphorescence of the film, and its rapid fading out, prove more than this. The molecular bombardment is too much for the thin film. It responds to it at first, but immediately gets heated by the impacts, and then ceases to be luminous. The plate, however, being thick, stands the hammering without getting hot enough to lose its power of phosphorescing.

Mechanical Action of Projected Molecules.

It was noticed that, when the coil was first turned on, the thin film was driven back at the moment of becoming phosphorescent, showing that an actual material blow was given by the molecules. Experiments are next described in which this mechanical action is rendered more evident. A small rotating fly, capable of being moved about in any part of an exhausted bulb, is used as an indicator, and by appropriate means the molecular shadow of an aluminium plate is projected along the bulb. When entirely in, or entirely out of the shadow, the indicator scarcely moved, but when immersed so that one-half was exposed to molecular impact the fly rotated with extreme velocity.

Magnetic Deflection of Lines of Molecular Force.

With this apparatus another phenomenon was investigated. It is found that the stream of molecules, whose impact on the glass causes the evolution of light, is very sensitive to magnetic influence, and by bringing one pole of an electro-magnet or even of a small permanent magnet near, the shadow can be twisted to the right or to the left.

The little indicator was placed entirely within the molecular shadow, no movement being produced. An adjacent electro-magnet being now excited, the shadow was twisted half off the indicator, which immediately rotated with great speed.

* "Proc. Roy. Soc.," Nov. 16, 1876, vol. xxv., p. 305.

The Trajectory of Molecules.

The amount of deflection of the stream of molecules forming a shadow is in proportion to the magnetic power employed.

The trajectory of the molecules forming the shadow when under magnetic influence is curved, the action of the magnet is to twist the trajectory of the molecules round in a direction at an angle to their free path, and to a greater extent, as they are nearer the magnet. The direction of twist being that of the electric current passing round the electro-magnet.

Laws of Magnetic Deflection.

An apparatus was constructed so that the deflection of a spot of light was used instead of that of a shadow; a horseshoe magnet being placed underneath the negative pole to deflect the trajectory. The action of the north pole being to give the line of molecules a spiral twist one way, and that of the south pole being to twist it the other way, the two poles side by side cause the line to move in a straight line up or down along a plane at right angles to the plane of the magnet and a line joining its poles.

The ray of molecules does not obey Ampère's law, as it would were it a perfectly flexible conductor, joining the negative and the positive pole. The molecules are projected from the negative, but the position of the positive pole, whether in front, at the side, or even behind the negative pole, has no influence on their subsequent behaviour, either in causing phosphoresence, producing mechanical effects, or in their magnetic deflection. The magnet only gives their line of path a spiral twist, greater or less accordilly to its power, but diminishing as the molecules get further off.

Numerous experiments were tried in this apparatus with different gases, and with the magnet in and out of position, and the following conclusions are arrived at:—

Working with exhausted air it was found that the spot of green phosphorescence on the screen was visible at an exhaustion of 102·6 M when the mean free path of the molecules, measured by the thickness of the dark space round the negative pole, was only 12 millims. Hence, it follows, that a sufficient number of molecules to cause green phosphorescence on the screen are projected the whole distance from the pole to the screen, or 102 millims., without being stopped by collisions.

Alteration of Molecular Velocity.

If we suppose the magnet to be permanently in position, and thus to exert a uniform downward pull on the molecules, it is seen that their trajectory is much curved at low exhaustions, and gets flatter as the exhaustion increases. A flatter trajectory corresponds to a higher velocity. This may arise from one of two causes; either the initial impulse given by the negative pole is stronger, or the resisting medium is rarer. The latter is probably the true cause. The molecules which produce the green phosphorescence must be looked upon as in a different state to those which are arrested by frequent collisions. The latter impede the velocity of the free molecules and allow longer time for magetism to act on them; for, although the deflecting force of magnetism might be expected to increase with the velocity of the molecules, Professor Stokes has pointed out that it would have to increase as the square of the velocity, in order that the deflection should be as great at high as at low velocities.

Comparing the free molecules to cannon balls, the magnetic pull to the earth's gravitation, and the electrical excitation of the negative pole to the explosion of the powder in the gun, the trajectory will be flat when no gravitation acts, and gets curved under the influence of gavitation; it is now also much curved when the ball passes through a dense resisting medium, it is less curved when the resisting medium gets rarer; and, as already shown, intensifying the induction spark, equivalent to increasing the charge of powder, gives greater initial velocity, and, therefore, flattens the trajectory. The parallelism is still closer if we compare the evolution of light seen when the shot strikes the target with the phosphorescence caused in the glass screen by molecular impacts.

Focus of Heat of Molecular Impact.

The author finally describes an apparatus in which he shows that great heat is evolved when the concentrated focus of rays from a nearly hemispherical aluminium cup is deflected sideways by a magnet on to the walls of the glass tube. By using a somewhat larger hemisphere and allowing the negative focus to fall on a strip of platinum foil, the heat rose to the melting point of platinum.

An Ultra-gaseous State of Matter.

The paper concludes with some theoretical speculations on the state in which the matter exists in these highly exhausted vessels. The modern idea of the gaseous state is based upon the supposition that a given space contains millions of millions of molecules in rapid motion in all directions, each having millions of encounters in a second. In such a case, the length of the mean free path of the molecules is excessively small as compared with the dimensions of the vessel, and the properties which constitute

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the ordinary gaseous state of matter, and which depend upon constant collisions, are observed. But by great rarefaction the free path may be made so long that the hits in a second are negligible in comparison to the misses, and the average molecule is allowed to obey its own motions or laws without interference; and if the mean free path is comparable to the dimensions of the vessel, the properties which constitute gaseity are reduced to a minimum, and the matter becomes exalted to an ultra-gaseous state, in which the new and very decided properties now under investigation come into play.

Rays of Molecular Light.

In speaking of a ray of molecular light, the author has been guided more by conciseness of expression than by a wish to advance a novel theory. It is considered, however, that the comparison, under these special circumstances, is strictly correct, and that he is as well entitled to speak of a ray of molecular or emissive light when its presence is only detected by the light evolved when it falls on a suitable screen, as he is to speak of a sunbeam in a darkened room as a ray of vibratory or ordinary light when its presence is only to be seen by interposing an opaque body in its path. In both cases the invisible line of force is spoken of as a ray of light, and if custom has made this correct as applied to the undulatory theory, it cannot be wrong to apply the expression to emissive light. The term emissive light must, however, be restricted to the rays between the negative pole and the luminous screen. The light by which the eye then sees the screen is, of course, undulatory.

The phenomena in these exhausted tubes reveal to physical science a new world—a world where matter exists in a fourth state—where the corpuscular theory of light holds good, and where light does not always move in a straight line, but where we can never enter, and with which we must be content to observe and experiment from the outside.

LITERATURE.

A Practical Introduction to Medical Electricity, with a compendium of Electrical Treatment. Translated from the French of Dr. Onimus. By A. de Watteville, M.A., B.Sc., London.

This little work, profusely illustrated with woodcuts, mainly representing the various apparatus manufactured by Gaiffe and by Trouvé of Paris, merits some notice in these pages, by reason of its being the first to insist upon the use of the British Association units of measurement in the medical application of electricity. Commencing with the assertion that electricity is a "force" and a "form of molecular motion," it concisely sets forth the less questionable and the verified conclusions which are summed up in Ohm's law, which it rightly designates as the "foundation stone of electrical science;" and thenceforth the *ohm*, the *volt*, and the *veber per second*, are referred to in all quantitative considerations. No small credit is due to the author, as a medical electrician, for the following clear statement of the fact that the only difference between currents (excepting density) is in their strength:—

"A current of a given strength, be it a current of water or electricity, or of any other 'fluid,' performs a certain amount of work, no more, no less. The current of water causes the wheel to revolve so many times in a minute; the current of electricity deflects a needle so many degrees, decomposes so many grammes of water, heats a wire to such a temperature, magnetises a piece of iron to such an intensity, exerts (within physiological limits) such an action upon the organism. With every change in the strength of the current, its mechanical, physical, chemical, or physiological effects will display a proportional change in their intensity. It matters not what be the source of the current; it may be chemical work, as in the case of the voltaic pile, or mechanical, as in Gramme's machine; its effects are the same, its strength being the same. It is idle, therefore, to attempt to show the superiority of this or that kind of element, except on the ground of convenience or constancy. Electro-motive force is one, and, the resistances in circuit remaining unaltered, the current is one, and the work done remains the same."

The author endorses as follows the suggestion made by Mr. W. H. Preece as to the use of the *milliveber*:—

"Practically, the current corresponding to the unit strength is comparatively rarely used. In most cases, among which are medical applications, the currents used are much weaker. Hence a proposition has lately been made which, I think, ought to be adopted, viz., of adopting the thousandth of a veber as a working unit, and call it a milliveber. As it happens, it exactly suits medical purposes, for a current of 1 m.v. is that given by about 3 Daniells through the average resistance of the human body. It is obviously simpler to speak of currents of 1, 5, 10, 20 millivebers than of ·001, ·005, ·01, ·02 vebers. These are the limits of medical currents. Hence, expressed in absolute measurement, 'weak' currents in electro-therapeutics are currents of 1—5, 'medium' from 5—10, 'strong' from 10—15, 'very strong' from 15—20 millivebers."

It will be seen that the author here confounds B·A with "absolute" units of measurement. As this mistake is of not uncommon occurrence, it may here be mentioned that the absolute metre-gramme-second unit of current is equal to one hundred *vebers per second*; whilst the absolute M.-G.-S. unit of electromotive force is only 1-100,000th of the volt, and the absolute M.-G.-S. unit of resistance only 1-10,000,000th of the ohm.

THE SPIRIT OF THE PRESS.

(BY AN AGED PENNY-A-LINER.)

What is the Spirit of the Press?—The answer used to be
Gin—with a modicum of water—and sitting up till three.
A lay-figure whose clothes
Were red,—like its nose,—
Or blue,—if to charm the blue voter,—
Was postured in prose
To edify those
Who subsidised best the "promoter:"
It breathed as does a bellows; lived and moved as does a mill;
And, if it had a being, it was nourished from the still.
Long it sighed to have a voice and a soul to call its own,
And when the dullest seasons came it stole away from Town
In search of great sea serpents, big gooseberries galore,
And patriarchs that lived to see a hundred years or more.
It tried the Ritualistic line, told how the lecterns burnt,—
But it made a lot of blunders—there was too much to be learnt.
The theologic vein was struck when philosophic mocking
At religion came in fashion, till it grew a little shocking;—
Then out came Popular Science! Now that's the very thing
Has given us vitality, and an independent fling
Upon a common platform. And our *rôle* you see at once is
To learnedly discourse to a world of learned dunces;—
For do not the masses
Attend evening classes,—
Everlastingly grinding out prigs,—
Who hear about gases,
And—though mostly asses—
Really think themselves very big wigs?—
To these "evolution," "protoplasm," "induction,"
Like Mesopotamia, are full of instruction.—
Then Electrophony followed; then the new Electric Light,
"Indefinite divisibles," and "priority of right,"
Came to aid us in our modest and laudable ambition,
Which, at the present moment, is to play the Electrician.
(For this and all the sciences our formulas are two:—
A thing *is* new if new to us: and, What is new is *true*.)
So now we've got a voice and a soul to call our own,—
The "scientific instinct" inside our motley gown.—
This is the spirit of the times, and the line we go upon:
We're only just beginning, but I think we're getting on.

J. L.

MORSE RELAY OF M. SERRA-CARPI.*

(PARIS EXHIBITION. ITALY—CLASS 65.)

This relay consists of a magnetised rod, forming a tongue, which oscillates between the two poles of an electro-magnet. When even a very feeble current passes through the coils of the latter, the rod is attracted to one side or the other, thus closing the circuit of a local battery.

The difference between this relay and others based on the same principle consists mainly in the following modifications:—

1. The magnetised rod does not work on a pivot; it moves to one side or the other by bending a very thin steel spring.

2. This steel spring (similar to those used for the suspension of pendulums) maintains the magnetised rod between the poles of the magnet, but allows it to close either the one or the other of two different circuits, according to the direction of the current transmitted through the coils of the electro-magnet.

3. The advantage of the steel spring over the pivot is, that it allows the sensitiveness of the apparatus to be regulated by shortening the spring, more or less, so that the direct current may just suffice to bring the extremity of the rod against one of the two stops, in order to close the circuit of the local battery. The return current (? current of discharge), being weaker than

*Translated from "Annales Télégraphiques."

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the direct current, is unable to overcome the elasticity of the spring so as to bring the rod over against the opposite stop. Thus the rod remains between the two poles of the electro-magnet, without any danger of the effects arising from the return current.

4. The construction of this relay is *very simple*, because *there is no fixed magnet*.

5. The sensitiveness of this simple relay is comparable to that of the best relays ordinarily used in telegraph offices, a fact which is established by the experimental trials made in the central office at Rome.

The receiving instrument is furnished with two sets of coils, corresponding to the two directions in which the current may be transmitted, and thus two different series of elementary signals may be obtained.

LAW INTELLIGENCE.

(COMMON PLEAS DIVISION, DEC. 20TH).

SIMM AND INGLELOW V. THE ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED)—THE ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED) V. SPURLING AND OTHERS.—This litigation arose out of the following circumstances:—Mr. Coates, of Parliament-street, a Parliamentary agent, was in November, 1874, the registered owner of 5,000*l*. stock in the Anlgo-American Telegraph Company, but in that month Phillips, a confidential clerk of his, forged a transfer of the stock, and sold it through Mr. Thompson, a broker. A transfer was made to Messrs. Spurling and Skinner, and a subsequent transfer was made to Messrs. Simm and Inglelow, as trustees for the National Bank, which bank had made advances to Messrs. Burge and Co. upon this stock and other securities. The object of the present proceedings was to have the rights of the different parties settled, or, in other words, to have decided who were to suffer for the fraud which had been perpetrated by Phillips.—Mr. Day, Q.C., Mr. Channell, and Mr. Bush Cooper; Mr. Watkin Williams, Q.C., and Mr. Finlay; Mr. Wadeley, Q.C., and Mr. Oppenheim appeared for the different parties.—Mr. Justice Lindley said that the forgery of Phillips was very skilfully executed, and there was no want of care on the part of anybody in not detecting it. His opinion was that Messrs. Simm and Inglelow having taken the stock without any notice of fraud, were entitled to have from the company the value of the stock. As to the second action, he thought that the company must bear the loss which had arisen in consequence of their having registered a forged transfer, and that they were not entitled to shift the burden that had fallen upon them to Messrs. Spurling and Skinner, Messrs. Burge and Co., or anybody else. The order which he should make would be that the company should pay to Messrs. Simm and Inglelow the value of the stock on the 1st February last, when they, having discovered the fraud, refused to pay the dividend upon the stock to those gentlemen. Upon the money being paid, the stock would be delivered up, and the company would be at liberty to rectify their register. The company would pay the costs in the first action, and in the second action the decision would simply be that there should be judgment for the defendant.

THE ELECTRIC LIGHT.—The first authoritative statement as to the details of Mr. Edison's electric light invention is given in the *New York Herald* of December 11 by a correspondent who examined the Edison electric lamp in Mr. Edison's laboratory. From the statement it seems that the patents we have heard of as having been granted recently at Washington in his favour were only two out of a very large series that have to be taken out. The system is a very complex one, and each part of it must be protected by patent. These parts correspond to the retorts, receivers, mains, &c., in gas manufacture and lighting. Mr. Edison himself did not know when the correspondent called what were the particular parts in respect of which patents had been granted. The light is produced by incandescence; the conductor, which is made incandescent by the electric current passing through it, is a small, curiously-shaped apparatus, consisting of a high alloy of iridium, which cannot be melted under 5,000 degrees Fahrenheit. Devices of exceeding simplicity and, as repeated experiments have proved, of equal reliability, are connected with the lamp. They surmount the apparent impossibility of regulating the strength of the light. This lamp, when placed in the electric circuit, in which a strong current circulates, is absolutely independent of the strength of the current. This Mr. Edison considers one of the vital features of the invention. If the regulator is set so that the light gives only, say, 10-candle power, no increase in the strength of the current will increase its brilliancy. This light is independent of all others in the circuit. A thousand may be fed from the same conductor, and the extinction of all but one will have no effect on that one. Each lamp in the circuit, by means of the regulator, the description of which latter Mr. Edison for the present withholds, is allowed to draw from the central station just sufficient current to supply itself. Since Mr. Edison undertook the problem of lighting by incandescence, many attempts have been made in the same direction, but owing to the lack of knowledge or misconception of the cost of electricity the improvements were such that as much current had to be supplied when the lamps were not lighted as when they were. Great loss was in consequence entailed.

TRAFFIC RECEIPTS FOR NOVEMBER, 1878.

COMPANIES.	Nov. 1878.	Nov. 1877.	Increase.	Decrease.
Anglo-American Telegraph Company	£51,090	£47,890	£3,200	—
Brazilian Submarine Company	12,753	12,233	520	—
Cuba Submarine Company	2,600	2,859	—	259
Direct Spanish Telegraph Company	1,001	885	116	—
Direct United States Telegraph Company	17,030 estd.	12,920	4,110	—
Eastern Extension Telegraph Company	25,280	20,794	4,486	—
Eastern Telegraph Company	37,170	38,439	—	1,269
Great Northern Telegraph Company	16,587	17,670	—	1,083
Submarine Telegraph Company	9,549	9,817	—	268
Western and Brazilian Telegraph Company	—	11,226	—	—
West Coast of America Telegraph Company	2,200	1,800	400	—
West India Telegraph Company	4,076 estd.	4,294	382	—

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES Dec. 23.		BUSINESS DONE WEEK ENDING Dec. 23. Highest.	Lowest.
Anglo-American	57,	⅛	57⅛	57⅛
Do. "B"	83½,	84	84	84
Do. "A"	32,	¼	32¼	32
Brazilian	6⅛,	⅛	6⅛	6⅛
Cuba	8⅛,	¼	8¼	8¼
Do. Ten per Cent. Preference	15,	¼	—	—
Direct Spanish	2,	¼	—	—
Do. Ten per Cent. Preference	9½,	10¼	—	—
Direct United States	11⅛,	¼	11¼	11¼
Eastern	7 3-16	5-16	7⅛	7 3-16
Do. Six per Cent. Debenture	101,	104	103¼	103
Do. Five per Cent. do.	100,	102	—	—
Do. Six per Cent. Preference	10⅜,	11	10¾	10¾
Eastern Extension	6 15-16,	7 1-16	7	6 15-16
Do. Six per Cent. Debenture	103,	106	—	—
German Union	8,	⅛	—	—
Globe Telegraph and Trust	4⅛,	5	5	4⅛
Do. Six per Cent. Preference	10⅛,	⅛	10⅛	10⅛
Great Northern	7⅞,	8	7⅞	7⅞
Indo-European	19,	20	—	—
Mediterranean Extension	2⅛,	⅛	2⅛	2⅛
Do. Eight per Cent. Preference	8⅛,	9½	—	—
Reuter's	9⅛,	10⅛	—	—
Submarine	215,	220	—	—
West India and Panama	1⅛,	2	2	1 15-16
Do. Six per Cent. Preference	7⅛,	8	7 13-16	7 13-16
Western and Brazilian	2⅛,	⅛	—	—
West. Union Seven per Cent. 1st Mort.	114,	118	—	—
Do. Six per Cent. Sterling	100,	102	—	—

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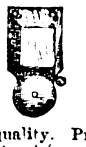
J. P. BEDFORD, *Secretary, pro tem.*



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NOTES.

TELEGRAPH LINES IN AMERICA IN 1852.—At the time mentioned there were 17,283 miles of line in Morse circuits, and 9,894 miles, with other instruments, making a total of 27,177 miles.

TELEGRAPHS IN SAIGON (FRENCH COCHIN-CHINA).—The first line was opened on the 27th March, 1862, and the wires now extend to every part of the colony, as well as to Cambodia; the system covers 1,300 miles, and includes forty-seven submarine cables.

WESTERN AND BRAZILIAN TELEGRAPH.—This company notify that their cable between Pernambuco and Bahia is now repaired, and that direct cable communication is thus restored between Pernambuco, Rio de Janeiro, Uruguay, the Argentine Republic, Chili, and Peru.

THE ARNAUD SYSTEM.—Rumour speaks of a large company about to be formed for the purchase and working of a patent granted to M. Antoine Arnaud, who was before Mr. Edison in the discovery and protection of a proven system of complete subdivision of the electric light. M. Arnaud, the discoverer, has himself been discovered and brought forward by Mr. Knowles, the Secretary of the Orleans Club.

INDIA RUBBER FROM ECUADOR.—The export of India-rubber during 1877 shows a decrease of 3,079 quintals compared with the year 1876. This has been partly caused by the exhaustion of the forests near the coast, the rubber being gathered much farther inland than formerly. It has also been in some measure caused by the unnavigable state of the upper branches of the rivers, swollen by the excessive rains. The following table gives the quantity exported during the six years—from 1872 to 1877:—

	Quintals.		Quintals.
1872	22,851	1875	6,990
1873	16,365	1876	10,138
1874	10,690	1877	7,059

THE ELECTRIC LIGHT: EDISON'S APPLICATION FOR A PATENT REJECTED.—It is reported from Washington that Edison's application for a patent upon a divisible electric light has been rejected by the Examiner at the Patent Office. The ground upon which a patent is denied is that Edison's invention is an infringement upon an invention for a divisible light made by John W. Starr, of Cincinnati. Starr, it appears, filed a caveat in 1845, which expired at the end of a year, and subsequently obtained a patent in England. He does not appear to have completed his patent-right in this country, as he died shortly after the issue of the English patent; but his caveat furnishes a sufficient bar to the issue of a patent on a like invention, as it proves previous discovery.—*Scientific News.*

SPAIN AND THE PHILIPPINE ISLANDS.—The Government is willing to grant a concession to any Spanish or foreign company to lay a cable between this and Hong-Kong, but want of capital, and, probably, also the onerousness of the conditions that the Government would be likely to impose, prevent the enterprise being taken in hand. It is only within the last few years that a wire has been laid down in the Philippines, and Manila is still unconnected with her principal outports. The lines at present working are:—Manila up to Bulacan, Pampanga, and Tarlac, thence through Pangasinan, in which is the port of Sual, and terminating in Ladac, to the north of Luzon. Southwards there is a line from Manila to Santa Cruz in the lake district, and from Manila to Batangar on the sea coast. Later on it is proposed to unite Manila with Albay, Yloilo, and Cebu.

POST OFFICE ANNOUNCEMENT.—On and after the 1st of January, telegrams for Germany and Holland will be charged for at the following rates per word, instead of at rates per telegram of twenty words and upwards as at present:—For Germany, 4d. per word; for Holland, 3d. These rates will be charged from the provinces as well as from London—the additional charge hitherto made for provincial telegrams being abolished. In like manner telegrams from Germany and Holland addressed to provincial towns in the United Kingdom will be charged the same rates as telegrams addressed to London. For a prepaid reply to a telegram, the charge will not be less than that for a telegram of ten words. If the sender of a telegram desires to prepay the charge for a reply of more than ten words, he must insert the number of words, but no prepaid reply may consist of more than thirty words. For an acknowledgment of the receipt of a telegram the charge will be the same as for a telegram of ten words.

TELEGRAPHY IN BRAZIL.—According to the last published report the extent of the lines has increased to 6,600 kiloms. The small number of stations (97) over this length, is represented as adding to the many other drawbacks in the matter of maintenance. The maximum number is limited to 104 over this distance, the only use of one-half of which is to facilitate and aid the service, seeing that the revenue is actually nothing, without even a reasonably remote prospect of the point being arrived at for the adjustment of deficits. As examples:—

20	stations	produce	less	than	£3 monthly.
10	„	„	„	 5	„
13	„	„	„	 8	„
8	„	„	„	 10	„

The annual expenditure in maintenance and fiscalisation of these lines is stated at 25,000*l.* The receipts from the State telegraph lines in 1876 were 29,284*l.* The relative expenditure was 168,333*l.*

DU FAY'S THEORY.—The difference in the electric action of excited smooth glass by dry silk, and that of sealing wax, &c., by fur, woollen cloth, &c., was discovered by M. Du Fay, intendant of the French king's gardens, about the year 1733, who, in consequence, introduced the terms *vitrious* and *resinous* electricity. After describing some other of his discoveries, Du Fay proceeds to describe the one in question in the following manner:—"Chance has thrown in my way another principle, more universal and remarkable than the preceding one, and which casts a new light upon the subject of electricity. The principle is that there are *two kinds* of electricity, very different from one another, one of which I call *vitrious* and the other *resinous* electricity. The first is that of glass, rock crystal, precious stones, hairs of animals, wool, and many other bodies. The second is that of amber, copal, gum lac, silk, thread, paper, and a vast number of other substances. The characteristics of these two electricities are that they repel

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themselves, and attract each other. Thus a body of the vitrious electricity repels all other bodies possessed of the vitrious; and, on the contrary, attracts all those of the resinous electricity. The resinous also repels the resinous, and attracts the vitrious. From this principle one may easily deduce the explanation of a great number of the phenomena, and it is probable that this truth will lead us to the discovery of many other things."

THERMO-ELECTRICITY.—We have at various times and in various places discussed the question, What part will Thermo-Electricity play in the future as regards Electric Lighting? The answer at present is not altogether satisfactory; yet we believe that by a simple arrangement the waste heat of almost any fireplace could be so utilised as to provide at least a sufficiency of electric light for an ordinary room. It is not to this point that we desire now to call attention, but to the waste of power in using the current from one dynamo-electric machine for the coils of the electro-magnets of the other. The following quotation will be read with interest, and probably suggest all that we intend to suggest at present:—"I desire here to record what I believe to be novel, that on the 27th of last June, with a thermo-electric pile, consisting of thirty pairs of bismuth and antimony, $1\frac{1}{2}$in. square and $\frac{1}{8}$in. thick, with the radiation of red hot iron at one extremity and ice at the other extremity, a soft iron electro-magnet, under the inductive influence of the electricity thus generated, supported ninety-eight pounds weight, the most powerful thermo-electric magnet I have heard of; but it must be observed that this is no maximum, for whoever employs a larger elementary battery will, no doubt, obtain greater effects, not only as regards inductive influence on soft iron, but all others in which the influence of temperature may be exerted. There is an ample field for investigation open for those who have leisure on this subject. Who knows but hereafter electro-magnetism may be employed as a prime mover, and that a thermopile may be the exciting cause?" [F. Watkins in Phil. Mag., Sept., 1837.] It may be that we shall have to record a speedy answer to this question.

MAGNETO-ELECTRIC MACHINES FOR LIGHTHOUSES.—The magneto-electric machine, adopted by MM. Sautter, Lemonnier, and Co., for the illumination of lighthouses, as shown by them at the Paris Exhibition, is a continuous current Gramme machine. When connected up "for tension," it gives a light equivalent to 2,500 Carcel burners, with an expenditure of 7 h.p., and 320 revolutions per minute; and, when arranged "for quantity," the light is equal to 4,000 of these burners, whilst 11 h.p. are expended, and the velocity is 550 revolutions per min. A similar machine constructed by the above-mentioned firm, and intended for the Planier lighthouse, was exhibited by the French Minister of Public Works. The reason for the adoption of the continuous current machine, instead of one with alternating currents is as follows:—In machines of the former class the light is concentrated on one of the carbons, whilst in those of the latter description it is equally divided between the two carbons, the distance between which, with the powerful currents now used, is from four to five millimetres at least. Now, if the middle of the arc be focussed in the lens, the horizon receives no light; whilst, if it be one of the two points, the light from the other is lost, being refracted either towards the sky or on to the sea in the vicinity of the lighthouse. The light furnished by a continuous current machine is therefore better utilised than that produced by one with alternating currents. By varying the speed of revolution, and by the use of a commutator, the above machines allow of the intensity of the light being varied, according to the condition of the atmosphere, in the ratio of 1:4, the expenditure of motive power being proportionate to this intensity.

THE ELECTRIC LIGHT.—Professor Charles A. Seeley, in an address delivered to the New York Academy of Sciences, has reviewed the history of discoveries in electricity in America and in Europe. The invention of the magneto-electric machines, he said, cheapened electricity and opened the way to new discoveries. In 1866 Horace Greeley was a member of an association which was formed to promote the use of the electric light. The fact that a brilliant light could be produced by the turning of a crank captivated his imagination, and he wrote several articles in support of attempts which were being made to perfect the light. "I freely declare my conviction," Mr. Seeley continued, "that the practicability of the electric light has been demonstrated at length. I do not say that the electric light will be made to take the place of gaslight, in the illumination of private dwellings, but I cannot doubt that it will be used to illuminate large buildings, public squares, and streets. The efficiency of the electric light is proved by its comparative cheapness. Professor Anthony, of Cornell University, has discovered that oil used in a steam-engine will produce an electric light three times as great as the light furnished by the oil when burned in lamps. He observed that the applications of electricity to the useful arts are among the greatest facts of our own times. In 1840, the world began to realise the possession of the arts of electro-metallurgy and electro-telegraphy. The publications which describe the electrical arts would constitute a large library. A single treatise (Du Moncel's) comprises 3,000 pages in five octavo volumes. Sir Humphry Davy, early in this century, exhibited the electric arc; in 1810 he employed for the purpose a galvanic battery of 3,000 cells. Since that time it has been familiar to the professors of chemistry and their students at all the large colleges; but it was regarded only as a curious fact or a brilliant illustration of science. Its great cost at first, and the annoyances of its management, did not give a resting-place for the suggestion that it would become a useful light. Probably Davy was also the first to obtain the electric light from incandescent platinum and carbon. In the year 1840 we commenced to have greatly improved generators of electricity, and so electricity came to be cheaper and more manageable. In 1844 the first patent was issued, and that to an American—Mr. Starr. From that year there has been a stream of patents, constantly increasing in volume. The electrical generators have been steadily improved, and the conditions of producing the electrical light are better understood. Electricity is now cheap, and we know how to use it. To-day the solid and permanent success of the electric light is achieved and guaranteed. Experience in its constant use as a light-house beacon extends back fifteen years. It is used and improved for the lighting of streets, theatres, workshops, and mines. It is established also that all the desirable qualities and properties of gaslight are found in the electric light, and that the latter has other desirable qualities in addition. The relative cost of equal quantities of gaslight and electric light will generally determine which shall be used; but there are many cases in which the advantages of electric light are so conspicuous that gaslight will not be thought of.

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THE PHONIC WHEEL OF M. PAUL LACOUR, OF COPENHAGEN.*

(EXPOSITION UNIVERSELLE OF 1878.)

M. Paul Lacour, whose name is well known through his interesting researches on simultaneous telegraphic transmission by means of harmonic apparatus, contributed in the Danish department a remarkable instrument to which he has given the name *phonic wheel*, and which is susceptible of numerous and important applications.

This wheel, which is properly speaking a small electro-magnetic machine, is so arranged that, when set in motion by electric vibrations produced by the action of an electro-diapason, it obtains a *rigorously uniform* movement of rotation which is not interfered with by any external mechanical reaction, which is not sufficiently powerful to arrest it. One can at once perceive the advantages that it offers in its application to chronographs, to telegraphs with synchronous movement, and even to acoustic apparatus.

Fig. 1 shows the phonic wheel reduced to its simplest expression. It is a toothed wheel of soft iron, moveable about its axis; facing which is placed a straight electro-magnet, so that one of its poles when excited reacts upon the teeth without contact, as in the case of electro-magnetic machines having a direct movement of rotation. If a series of currents having equal duration and intervals, as transmitted by an electro-diapason, be sent through the electro-magnet, the reaction of the latter upon the teeth results in a series of attractive effects which may be capable of maintaining an initial movement communicated to the wheel, and even of rendering this *perfectly uniform*, when the rapidity of rotation is such *that the wheel traverses, in each period occupied by a current, a space equal to the distance between two consecutive teeth.*

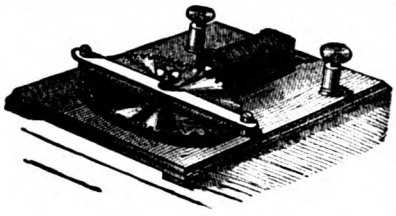

FIG. 1.

These currents, thus transmitted, are distributed by an electro-diapason, the arrangement of which is shown in Fig. 2; and the

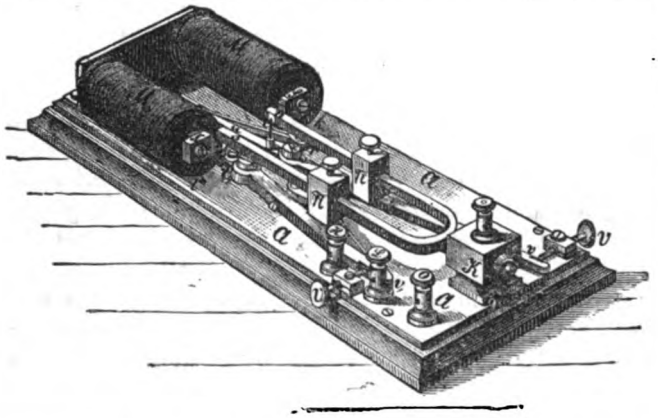

FIG. 2.

connection of the two apparatus with each other and with the battery is indicated in Fig. 3.

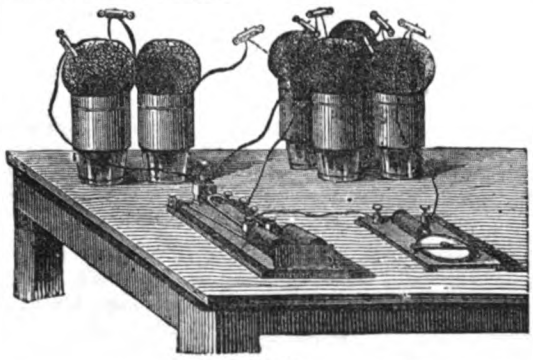

FIG. 3.

In order to understand the mode of action of the apparatus, let us examine what takes place when a tooth of the phonic wheel passes in front of the electro-magnet which influences it. Let us suppose that radii of the wheel passing on either side of a tooth are represented by the lines $r\ s$, $r\ t$ (Fig. 4), the line m indicating the position of the polar axis of the electro-magnet. Then let us consider what will take place when the pole m is presented to the middle of the tooth, also in front of it and behind it. These three cases are represented in Figs. 4, 5, and 6.

It is obvious that in the first case, represented in Fig. 4, the action exerted upon the tooth being the same on either side, the wheel will be in a condition of equilibrium, and its velocity will not be influenced by the magnet. But it will not be the same in the two other cases; for, in that represented by Fig. 5, an acceleration should result from the action of the magnet tending to make the line $r\ s$ coincide with its axis, whilst in the case shown by Fig. 6 there should be a slackening of the speed by an attraction in the direction of $r\ t$.

Thus it will happen that if the depressions between the teeth are presented successively at s (Fig. 4), at the moment when the attractive effect commences, the velocity of the wheel will undergo, it is true, in virtue of these intermittent attractions, *a variation during each wave*; but the mean velocity of the wheel will not undergo any variation, and, all things considered, the wheel will be during its movements in a condition of equilibrium in relation to the intermittent attractions.

FIG. 4. FIG. 5. FIG. 6.

The position obtained at each moment by this wheel in mobile equilibrium is evidently a function of the time, and we will designate it as the position of mobile equilibrium. One can ascertain that it really exists by slightly urging or retaining the wheel in its motion. In fact, if the movement be opposed, the attraction will accelerate it more than it retards it; and the velocity at t will then be greater than at s. If, on the contrary, the velocity of the wheel be augmented, the retarding action will be greater than the accelerating action; and the velocity at t will be less than at s. There will, therefore, be compensation; and since a slight deviation communicated to the wheel in either direction is compensated and rendered null, in virtue of the compensating attractions, the mobile equilibrium of which we have spoken constitutes, in fact, a condition of stable equilibrium.

"Experience," says M. Paul Lacour," "confirms this theory. If an electro-magnetic diapason is caused to react upon a current traversing the electro-magnet of a phonic wheel, according to the arrangement shown in Fig. 3, this wheel, when once it has obtained a movement which causes one tooth of the wheel to pass in front of the electro-magnetic pole during each electric wave, will preserve a condition of uniform movement which we will term a *regulated movement*, and which is analogous to, and in many respects resembles the condition (that of repose) of the wheel when one particular tooth is attracted in the direction of the pole.

"If the phonic wheel be travelling with a regulated motion, and an external force tends to deviate it somewhat from the position of mobile equilibrium, the phono-electric current tends to bring it back again to this position. But, if this force remains constant, the wheel, whilst still preserving its velocity of rotation, will find another position of mobile equilibrium, which will depend upon the extent of the force and its direction in reference to that of the rotation. Now it is this constancy in the velocity of the phonic wheel, in spite of external forces which may act upon it, that allows it advantageously to be applied to chronographs and to apparatus in which a synchronous motion is necessary. These forces, however, must not exceed a certain limit; for the wheel turns only in virtue of a force represented by the difference $s\ m - s\ t$, and which cannot obtain a higher value than $+ s\ t$ or $- s\ t$. And, if the external force should exceed this value, the mobile equilibrium is destroyed, and in this case the velocity of the wheel can be accelerated or retarded, according to the direction of this external force.

"The maximum mechanical force hitherto measured is one kilogrammetre (7·23 foot-pounds) per minute.

"Besides the above-mentioned regulated movement, there are certain other velocities at which the phonic wheel may be, and may maintain itself, in a position of mobile equilibrium. Thus, if the wheel turn with a velocity only half that which corresponds with the regulated movement, so that one tooth passes the pole for every two waves of the phono-electric current, the relation of each tooth to one of the two waves will be exactly the same as that of which we spoke when we considered the wheel in regulated movement, and this wave will maintain the stability of the mobile equilibrium, which might even be maintained by the

* Translated from *L'Electricité*.

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other wave, if the magnetic pole and the teeth of the wheel presented a sharp angle.

"Similar considerations are applicable also to other velocities, and we may arrive at the general conclusion that *the phonic wheel can maintain itself in rotation with velocities which are the nearest sub-multiples or multiples of the velocity of the regulated movement of rotation*. Consequently, the movement might be obtained with velocities equal to two-thirds of or to one and a half times that constituting the regulated movement; and these are the velocities that would be obtained by the phonic wheel in a regulated movement determined by phono-electric currents corresponding to a sound one-fifth lower or higher.

"It need scarcely be mentioned that, at all these velocities, the phonic wheel turns equally well in either direction."

By reason of the frictions and the external actions that can influence it, the phonic wheel is susceptible of a uniform velocity only between certain limits. The limit depends mainly upon the construction of the wheel, and its extent is but very small if there be in the neighbourhood any electrical conductors capable of influencing the wheel by induction. Amongst the phonic wheels experimented with by M. Paul Lacour there are some that would work only with a velocity determined by 100 waves per second, whilst others would work only under the influence of a phono-electric current giving 600 waves in the same space of time. Moreover, the *angular velocity of the phonic wheel* depends, not only upon the acuteness of the sound given out by the vibrating apparatus, but also upon the number of teeth. M. Paul Lacour has tried wheels having 18, 20, 24, 30, 36, 60, and 100 teeth, and he was able to obtain with all these wheels a regulated movement under the influence of a rather acute phono-electric current, without being able to decide which number produced the movement with the greater certainty. Nevertheless, it is very difficult to set in motion wheels having only a very small number of teeth, and which have, consequently, a great velocity of rotation.

In regard to the lineal velocity, M. Paul Lacour has shown that a phonic wheel, with 18 teeth, in which the distance between the median lines of two adjacent teeth was 20 millimetres, can turn with an interrupted phono-electric current, giving 245 waves per second, which gives as the lineal velocity $245 \times 21^{mm.} = 5^{m.}145$, or about 20 kilometres per hour. The apparatus can, therefore, be of great service when a high constant velocity is required.

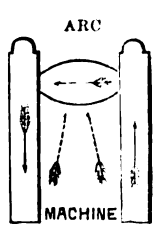
It would appear that the acuteness of the sound corresponding to the rotation of the phonic wheel has a *minimum*, for the movement seems to be uncertain when it is due to phono-electric currents produced by very deep sounds.

(TO BE CONTINUED.)

NOTE ON THE ELECTRIC LIGHT.

It has for some time been known that the insulating material in the Jablochkoff electric candle was only partially successful because, when it became heated, the resisting power was immensely diminished, so that there was a great loss of current through leakage from one carbon to the other. Now, Mr. Wilde has experimentally ascertained that the employment of this insulating substance is also quite useless, since, contrary to expectation, he found that if he used a Jablochkoff candle with only air between the carbons, the electric current passed from carbon to carbon merely at the top and not along the whole length, and, further, that if the arc were started (by means of a wire placed and withdrawn) at any other part of the parallel carbons than at the top, it at once proceeded to the top, at which place *alone* it continued to shine.

On the lamp being shown me, on December 5th, at the works of Messrs. Latimer Clark and Muirhead, by the kindness of those in charge, I was informed that Mr. Wilde attributed this rather curious effect to the convective action of the heated air, considering, in fact, that the air was blown up to the top of the carbons very much as a lighted piece of paper is blown up a chimney. Thinking it desirable, however, on that occasion to make some experiments to determine the real cause of this phenomenon, a few preliminary ones soon made it evident that, while convection of the air greatly assisted the action, the fact that the arc would travel downwards if the lamp were inverted and lighted at the now upper part of the carbons, near the metal carbon-holders, proved that the cause of the motion was not only quite distinct from air convection but was sufficiently strong to overcome such convection. Eventually it occurred to me that the explanation was none other than that this motion was caused by the repulsive action between the currents in the carbons and that constituting the arc itself, in accordance with Ampère's law concerning the action of a current on another at right angles to it. The above figure, in which the continuous arrows indicate the directions of the currents, and the dotted arrows the line of action of the repulsive forces, show this action clearly. The carbons are placed farther apart in the figure than they are in reality merely for convenience of drawing. The two forces are oblique to the carbons, but the resultant is parallel to them, and will always be away from those ends of the carbons which are connected with the magneto-electric machine, no matter how often the whole current be reversed.



Scientific Club, Dec. 20, 1878. W. E. AYRTON.

MR. EDISON'S INVENTIONS.

On Monday evening last, before a crowded and appreciative audience, Professor Barrett delivered, at the London Institution, a Lecture on "The Phonograph, Tasimeter, Carbon Telephone, Quadruplex Telegraph, and other Inventions of Mr. Edison." The wall at the back of the lecturer was covered with diagrams, to which he frequently referred in illustration of his remarks, and on the table were various of the inventions of Mr. Edison.

Professor BARRETT, in his opening remarks, observed that twelve months ago, when he addressed them on the subject of the electric transmission of music and speech, he noticed that a discovery had been made in the same country which gave birth to the speaking telephone, whereby the voice could be recorded and reproduced by simple machinery. Edison's name was, however, known to scientific men before his invention of the phonograph chiefly through additions he had made to the resources of telegraphy—additions alike remarkable for their originality and ingenuity. In view of these facts, and of the still wider interest which his investigations on the subdivision of the electric light had aroused, an apology was hardly necessary for speaking to them on that occasion on Edison and some of his inventions, for, although he would have to refer to the telephone again, it would be an entirely different instrument to any they examined last year. Edison was born in 1847, of humble parents, and his schooling was poor and fragmentary; but, as in the case of the illustrious Faraday, his real education began when his boyhood ended. At twelve years of age he had to earn his bread as a train boy, selling newspapers in the moving cars. In the corner of a luggage van he rigged up a small chemical laboratory, and he used to make experiments in the train. A primitive printing press and some old type having come into his possession, he picked up sufficient knowledge of printing to enable him to start a diminutive weekly newspaper, a rough and small sheet, called the *Grand Trunk Herald*, filled with items of news gleaned in transit, but sufficiently important to be noticed by *The Times* of London as the only newspaper ever printed in a train. Edison afterwards entered a telegraphic office, and before he was twenty not only made himself an expert telegraphist, but was able to repair and improve upon the instruments in daily use. His first success seemed to have been the invention of an instrument for printing gold and stock quotations, which brought him into the notice of the leading telegraph company in the United States—the Western Union Telegraph Company, who subsequently secured his services in a capacity unknown in England—as their *professional inventor*. Here his peculiar genius had soon to develop itself, and his inventions succeeded one another with astonishing rapidity, their quick succession being equalled only by their remarkable practical success. Though not yet thirty-two years of age he had already taken out 300 patents. This large number was accounted for by the peculiarity of the American patent law, many patents being required to protect a single invention—for instance, forty patents for his stock telegraph instrument, forty-six for his automatic telegraph, &c. At the present time he had a large staff of assistants engaged in carrying out his work. [A photograph of Edison at his instruments was here thrown on the screen.] The success of his inventions implied indefatigable work. The public saw only the results, and were prone to imagine that the inventions of which so much had been heard of late sprang ready accomplished from the fertile brain of Mr. Edison. The truth, however, was just the reverse. It was a trite, but true remark, that successful work in any direction—and notably in scientific discovery—was the result of patient, persistent toil, and Edison's inventions could only be the offspring of incessant work, profound technical knowledge, and the ready resource under difficulties which characterised a mechanical genius. Whilst thus recognising his merit he (the lecturer) had no doubt that Mr. Edison would shrink from the exaggerated estimate of his capacities which the English public had formed.

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Punch's Almanac for this year bore amusing witness of the glamour which the novel inventions of Edison had thrown around his name. On the contrary, among scientific men a strong prejudice against Edison had arisen from the impression which sensational newspaper interviewers had given of Edison himself, so that while on the one hand Edison was spoken of as if he were a Davy, Faraday, and Tyndall all in one, on the other he was regarded as little short of a charlatan. He hoped the present lecture would enable them to form a juster estimate of the man. One of the earliest and simplest of Edison's inventions was the so-called electric pen. Here a very swift to and fro motion was given to a needle point by means of a tiny electro-magnet. The object was to puncture the paper by the pen so that the record of the handwriting was left in a myriad of minute holes. A stencil plate was thus formed from which many hundred impressions could be taken by means of an ordinary copying press. Within the penholder was a needle, the point of which projected scarcely a hundredth of an inch beyond the sheath. At the upper part of the penholder was a small fly-wheel, the shaft of which formed a tiny crank which was attached to the needle. As the wheel revolved the needle point was rapidly thrust out and pulled back just like the sting of a bee. The revolution of the fly wheel was accomplished by a small electro-magnet, animated by a single voltaic cell. The noticeable feature in Edison's inventions was that in general they contained a new principle, some original observation in experimental science, which entitled him to the rank of a discoverer as well as an inventor. Such was the character of the electro-motograph—an entirely new method of receiving telegraphic messages, discovered by Edison in 1872. As every one was aware, the ordinary system of telegraphy depended upon the production of magnetism by means of an electric current, but Mr. Edison made the curious and important discovery that messages could be received by the well-known Morse recorder without the use of any magnet. All that was necessary in this simple telegraphic instrument was a band of moistened paper drawn beneath a metal style. The accident of holding his finger against the style led Mr. Edison to notice that when an electric current passed from the paper to the point resting upon it the friction of the moving pen was lessened. Hence, if the paper were drawn forward with a uniform force it would slip more easily beneath the point the moment the current passed. The lecturer then illustrated the arrangement adopted by Mr. Edison, whereby this slipping motion is converted into signals. It was necessary to moisten the paper with a solution of certain chemicals—potash was at first used, but a solution of sulphate of iron or common salt and pyrogallic acid was found to be best. The advantage of this instrument was said to be its extreme sensitiveness, it having been worked over a circuit of 200 miles, with only two cells, so that with weak currents, unable to affect ordinary istruments, the electro-motograph could receive messages. More than this, the speed of its working was greater than with the ordinary instruments. Using it as a relay it was said to have been worked at the rate of 1,200 words per minute—an average of 6,000 letters of four signals each, making altogether 24,000 waves per minute. Beautifully simple as was the principle of the electro-motograph practical difficulties had, he believed, arisen in its working, so that at present it had not come into use—in this country at any rate. The wonderful promptness of motion of the electro-motograph and its ready response to feeble currents, led Edison to use it as a telephonic as well as a telegraphic receiver. The instrument was not, however, adapted for the reproduction of speech, but the motograph telephone was of earlier date than the speaking telephone invented by Professor Graham Bell in 1876. In this discovery they obtained a characteristic glimpse of Edison. If Faraday had noticed the curious slipping of the paper under the action of a current, he would not have rested till he had found its *cause*, and proceeding onwards from such an incidental observation Faraday would probably have established some law of wider application, opening new regions of natural knowledge, the applications of which would come in due time by other hands than his. Edison, on the other hand, seized the *fact* itself, and at once applied it to purposes of practical utility. Both types of men were necessary; the intellectual progress of the age due to the one, the material progress to the other. The passion for invention was as genuine as the passion for discovery. One of the greatest triumphs in the modern development of telegraphy was the transmission of four different telegraphic messages simultaneously along one wire. Incredible as this would appear to many, it was not only possible, but was in actual and extensive use; and the successful solution of this problem was due to Edison. Though less popularly known, this achievement was, perhaps, the most important piece of work, from a practical point of view, which Edison had yet accomplished. Without entering into details it would be sufficient to say that the quadruplex system made use of the fact that currents of electricity might be made to differ in two distinct ways—in direction and in strength. This invention Edison brought to so practical an issue that it rapidly came into use in the United States. A year or two later on an incidental defect in the working was remedied by Mr. G. Smith, and nothing now prevented the general adoption of this system. At the present time it was in use between all the principal cities in the United States, in no less than sixty circuits, and, as regarded England, he learnt that it was at present in use on several long circuits, such as London to Leeds. Middlesboro', and West Hartlepool, and would shortly be extended to other lines. But our longest circuits were short compared with those in the United States. Great speed in signalling could also be attained in spite of the fourfold power of the line. The growth of discovery and invention resembled that of a living organism, the limit of to-day becomes the starting point of to-morrow. In quadruplex telegraphy it was essential perfectly to balance the electric currents. The common method of doing this was to employ great lengths of resisting wire, which were both expensive and somewhat tedious to adjust. A simpler arrangement for this purpose was devised by Edison, consisting merely of a pile of discs of silk, each of which had been rubbed with plumbago. From this arose the useful but simple contrivance called the carbon rheostat, involving an important principle which Edison might justly claim to have made his own. The principle involved was the effect of pressure on the electric conductivity of solids; hence, by squeezing powdered carbon a considerable variation in its conducting power was produced. The first use to which Edison put this curious property was the construction of an instrument he called a "carbon" or "pressure relay." This instrument was the father of a numerous family, for it contained the germ of the carbon telephone, the microphone, the tasimeter, and the carbon rheostat, just mentioned. Referring to the carbon telephone, the lecturer remarked that, when speaking a year ago of the telephone invented by Professor Graham Bell, he said that "it was unlikely the telephone of the future would employ the voice to generate the driving power as it does in the magneto-telephone, but only to modulate the flow of a current obtained by coarser means. It is in this direction that Mr. Edison is working." Since then Mr. Edison had completed his telephonic experiments, having constructed an instrument by which conversation could be carried on between places 750 miles apart, and within the last month or two had devised a new receiver for his telephone, which, on short circuits, would deliver the voice in a tone even louder than that in which it was originally spoken. After speaking of the mechanism of the telephone, and illustrating on the screen its gradual growth, he further alluded to the receiver without any magnet, which was devised by Edison, owing to an objection of the Bell Telephone Company. The lecturer, in conclusion, turned to the phonograph, the invention by which Mr. Edison was best known, and explained of what it consisted. The extreme simplicity and apparent inadequateness of its parts was the first thing which struck an observer: there was nothing there that was not known long ago, and nothing that might not have been tried, if not accomplished, with equal success by the merest tyro in science. Another application of it had lately been made by Mr. Edison, in which the sound of the voice was made to move a mill, a small model of which the lecturer showed, and which he not inappropriately described as a sound mill.

The lecturer closed his remarks amid the most hearty applause.

EDISONIA.

A reporter of the *New York Sun* had an interview on the 18th of December with Mr. Edison. Mr. Edison stated that several patents for the electric light had been granted him at Washington; but, as the particulars were kept secret until the patent was taken out, and as he did not intend to take them out inside of six months, the limit allowed him by the Patent Office, he should postpone his final experiments for lighting Menlo Park until he found the machine that would give the greatest amount of electricity per horse-power. Meanwhile, he was making many little generators of different forms for the purpose of arriving at this knowledge. He estimated that the total number of generators he would use in his final experiments in lighting the park would cost him from 6,000*l.* to 8,000*l.* He proposed, in the case of the little experimental generators he was making, to run them with weights. Estimating all the expenses, with the poorest engines and the poorest economy, where, in fact, the expenses were very high, if he could get six lights per horse-power (and he was confident on this head), each light would cost, in his belief, only one-third the amount the production of the same amount of light by gas cost.

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THE ELECTRICIAN.

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ELECTRO-CHEMICAL ENGINEERING.

Few electricians can have failed to notice that the tendency of the applications of electricity, of the arts that originate in electrical science, is to become branches of the great art of engineering, which, based on mechanics, embraces in its gradual growth the fruits of a multitude of sciences. Romagnosi and Œrsted observe the deflection of a magnet by the current from a voltaic battery, Sturgeon observes the production of magnetism in soft iron by the same agency; and on these observations Gauss and Weber, Steinheil, Cooke and Wheatstone, and Morse, lay the foundations of Electro-Telegraphic Engineering. Spencer and Jacobi observe the deposition of a metal at the cathode within an electrolytic cell; and in due time Elkington and Christofle develop electro-metallurgy into what now bids fair to become the art of Electro-Metallurgical Engineering; Davy discovers the electric light and the voltaic arc by means of the colossal but comparatively inefficient battery of the Royal Institution; and we have now, springing into sudden activity, the art of Electro-Photological Engineering, which, in the eyes of the public, has given a new interest and a new importance to things electrical. The tendency we notice is, of course, due, in very great measure, to the discovery by Faraday of magneto-electricity, and to the inventions of Pixii, Saxton, Clarke, Nollet, Holmes, Van Malderen, Wylde, Siemens, Pacinotti, and Gramme. The present century, as M. de Meritens recently observed, has seen the birth and the growth of the steam engine and of the electric current, and will witness the association of these two powerful agents. Electricity, no longer contented with zinc, has seized upon coal as a source of energy; and the practical importance of the science of which we record week by week the progress has already become augmented in no small measure by the substitution of the primary electro-positive for one which receives its potential energy from it at second-hand.

But it is quite possible that the present century may witness in the direction of Electro-Chemistry, applications of electricity, and of the steam engine in conjunction with it, on a larger scale than any now contemplated. Within a few weeks of the announcement of the discovery of Volta's pile, Nicholson and Carlisle decomposed with it water and various salts. We have long known that the electric current is the most direct and powerful agent for effecting those changes in the constitution of matter, whereby the compounds presented to us by nature are converted into others, or resolved into elements, of varied utility to mankind. This knowledge has hitherto not only been without a useful practical result, it has even been disastrous. The attempt by Nollet to obtain the gases for the oxyhydrogen lime-light by the electrolysis of water, and the futile results obtained by a certain "Electric Light and Colour Company" in this country appear to have discouraged all applications of electro-chemistry. Even the theory of this branch of science has been very generally neglected; and the researches of the few investigators who have given special attention to it have received no encouragement. Electro-Chemical Engineering is altogether a matter of the future, but very probably of the immediate future. Seven years ago the leading English journal on engineering questions referred to it in the following terms:—"The sisterhood of chemistry and electricity has been recognised ever since the latter became a science; but the close relationship of both to mechanical dynamics, although known in theory, has received such scant recognition, that very many scientific engineers might at first almost regard as an impertinence such questions as, 'How many horse-power would be required to convert, in sixty hours, a ton of lead into 1 ton 2cwt. 57lb. of plumbic peroxide?' or, 'How many foot tons of work might it take to reduce electrically the metal in a ton of malachite.'"* We may add that some electricians might regard such questions in the same light, although their science supplies the data by which they may, under given conditions, be solved. And those who know least on the subject of electro-chemistry are, perhaps, the most inclined to assert that its application to the manufacture of chemical products is commercially impracticable, if not absurd.

Recent researches have, indeed, given results which, however instructive, are somewhat startling as regards the quantity of work which requires to be stored up in certain products of electrolysis before these can be obtained. Thus, in decomposing a ton of common salt in solution, no less than 1,319,000 foot-tons of work are required to be stored

* *The Engineer*, Jan. 5, 1872.

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up in the chlorine, hydrogen, and sodic hydrate, which are separated. Practically, at least an equal quantity of work is converted into heat in the electrolytic circuit. Now, the sum of these quantities, on the assumption that an expenditure of 2·5lb. of coal per hour will give 1 h.p., represents 6·6 tons of coal, without taking into account the energy converted into heat by friction. More than ten tons of coal would undoubtedly be consumed in the electrolytic production of one ton of caustic soda and its equivalent weight of chlorine. And it may here be observed that only six tons of coal (besides sulphuric acid, &c.) are consumed in the ordinary manufacturing operations for the conversion of common salt to produce 20cwt. of alkali (60 per cent. caustic). It must be confessed that the data in the present case do not appear very encouraging, especially when it is considered that steam power equal to 373 horses would be required to effect in twenty-four hours the decomposition resulting in one ton of caustic soda and its equivalent of chlorine, and more especially when the construction of the decomposing tanks and other apparatus is duly regarded with reference to the question of *time*.

We should not, therefore, advise any manufacturer to commence operations in electro-chemical engineering with a view to the production of alkali and chlorine, to be disposed of as articles of trade requiring storage and transport; and, although the case is essentially different, and far more advantageous, we might even hesitate to recommend the bleacher who requires to use these articles on the spot, and who might produce them according to his needs, to take any step in this direction otherwise than tentatively. But we do not hesitate to express the opinion that in the latter case an experiment on a small scale should be tried, on the grounds that the probability of a small loss is amply compensated by the reasonable possibility of a great commercial success. And in other directions the field is wide, and, we doubt not, affords many opportunities of substantial success to those whose industry and enterprise are commensurate with their knowledge of what is required in certain branches of manufacturing chemistry. It is in the direction of the more rare and expensive salts and chemical products that the first openings for Electro-Chemical Engineering are to be found.

The value of a dynamo-electric machine in conjunction with an electrolytic decomposition tank is not to be measured merely by the results which can be obtained in the centres of civilization, but should be tested wherever fuel is plentiful; and certain natural products are as readily obtainable as manufactured products are scarce and in demand. We hear of copper, nickel, and even gold, which will not bear transport by reason of the large percentage of foreign matter from which they cannot mechanically be separated, but which would be readily obtainable if chlorine for their solution and hydrogen for their reduction were available; and we need scarcely state that these elements may often be cheaply generated by means of a dynamo or magneto-electric machine. And there are localities where the cheap production, on the spot, of the solutions (alkaline and acid) for *bucking* and *souring* might not only encourage but originate the manufacture of textile fabrics, or of the fibrous materials requisite for it, and where nitrate of potash or soda might very advantageously be directly converted into nitric acid and alkali. And nearer home also there are many opportunities for utilising or economising substances that are now useless and allowed to run to waste. Certain it is that the first substantial success in the direction of Electro-Chemical Engineering will cause a rush of inventive talent in this direction; and it is probable also that it will directly lead to the most important, from a commercial point of view, of all the applications of electricity.

1878.

Before these lines reach the public eye, 1878 will be numbered with the years that are gone, and we shall have passed the threshold of the new year. It is a good old custom to greet our friends with kindly words of cheer and sympathy at the commencement of each new year. We are glad that the custom exists, as it enables us to thank all those who have aided our youthful steps, and will have aided us to bask in the sunshine or rest in the shadows of a new year. We heartily trust that the new year may be one of abundant prosperity and happiness to all who read these lines. We hope, with the continued aid which has been so generously tendered, to tread the hidden paths of the future in safety, culling and garnering the knowledge that nature is ever ready to give, and to assist in rearing a scientific structure that shall set forth clearly those great salient laws of electrical science, without a thorough grasp of which the student but goes onward to stumble. An ever-increasing support has hitherto attended our efforts, and we hope, with renewed care, to eradicate those weak points in our scheme and in our practice which to some may be obvious, and to make *The Electrician* a complete and faithful record of electrical science in all its multitudinous branches.

The past year has been one of surpassing interest. The wonderful discoveries of Professor Hughes, the practical introduction of the Electric Light, the important experiments of Mr. Crookes, all help to mark it as one of the red-letter years of electrical science. The Telephone—that marvellous instrument, the result of the combined efforts of Mr. Elisha Gray, Professor Dolbear, and Graham Bell, was the legacy given to us by 1877; the Microphone, which one is almost constrained to say is the natural outcome of the Telephone has been given to us by Professor Hughes in 1878. True, it is asserted that Mr. Edison claims the discovery as his, and that Professor Hughes was simply a co-discoverer. Suppose we concede the point, and then look at the facts as patent to all of us. Mr. Edison was pursuing investigation for a certain purpose, he was let and hindered by various phenomena which he looked upon in the light of evils, and relegated them to the regions of inventors' troubles. Professor Hughes, with a thorough grasp of the laws of electricity, by a train of inductive reasoning, corroborated at every step by a series of delicate experiments, gradually pushed forward his discoverries till he startled the whole scientific world with his paper presented to the Royal Society, which contains the final results of months of toil and anxiety. It is to Professor Hughes that the actuality of the Microphone is due, and it is his work that has given an impetus to the thoughts of a thousand and one students who are now busily engaged trying to push discovery further into the dark background of the unknown. It is an extraordinary and almost unparalleled example of the completeness of scientific investigation, for be it noticed, that although the whole scientific world has dabbled more or less with the work, no new principle has been added to those given by Professor Hughes. Modifications of the apparatus have been made on every hand, and that is all. Can greater praise be given than to state such facts as these? In any other country than England Professor Hughes would have been offered a well-merited reward. Where is the courtesy of our Royal Society? Is the *entrée* to this Society still the blue ribbon of science! Are the ranks that contained a Davy and a Faraday to be closed against merit because merit is too modest to seek a place therein?

The first number of *The Electrician* was published on May 25th. Its organisation, as has been surmised in many quarters, is intimately connected with the International Conference, which was to have held its triennial sitting in London last year; but, owing to the grave political disturb-

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ances in Europe, the meeting was postponed to 1879. The decisions of this Congress are of the utmost importance to the success of international traffic, and we need hardly point out that the very existence of cable work depends upon them. The various Governments concerned do not always consider fully the effects their propositions will have if carried into operation upon the various companies. It is absolutely necessary, therefore, that the companies should have justice; their capital is very large, and the interests involved not such as can be safely overlooked. International commerce owes much to submarine telegraphy, and the energetic management with which the system is conducted. The shareholders do not receive high dividends, and their receipts are liable to stoppages from causes no foresight can prevent. The meetings, then, of these International Telegraph Conferences should be carefully considered, and the public interested should be made fully cognisant of their actions. It is part of our scheme to discuss the questions brought forward at the meetings as completely as possible. Major Webber, during the discussion which arose on the reading of his paper at a late meeting of the Society of Telegraph Engineers suggested an exhibition of electrical and telegraphic apparatus during the meeting of the forthcoming Conference. This suggestion is well worth consideration, and, if carried out, a working committee should be formed at once, as the time during which the exhibition can be organised is none too long for the perfection of such a scheme. An exhibition of this kind should meet with the willing co-operation of all the governments interested, and of the various manufacturers on the Continent, and at home. We believe that if the idea was heartily supported by the Post Office authorities, the exhibition would be a great success.

The past year saw another of the grand fairs of the world. Paris has been the centre of attraction in more than the ordinary sense for all who travel. The electrical apparatus exhibited, however, had the fault of being scattered in various portions of the vast building. However important it may be to keep the exhibits of each nation together, it is more important that the visitor should be able to classify and compare machines of a complicated character. But at Paris, with certain exceptions, it was impossible to do this. We have, however, from time to time commented on the exhibits at Paris, and shall continue to do so, either by specially written descriptions or translations. Count Th. du Moncel has made these descriptions a labour of love, and, as far as possible, we have translated his papers. It is, however, to Paris that we owe the great excitement over the "Electric Light." Several important streets and large buildings in that gay capital have for months basked in the blaze of the electric light. Visitors could not help being struck with the feebleness of the gas when compared with this, so to speak, new rival. Undoubtedly, the old oil lamp was better than nothing, and gas is better than oil. Gas did not supersede oil because it was cheaper, but because it gives a better light. We doubt if electricity will supersede gas on the ground of economy, as economy is generally determined, but because the greater light enables us to transact business with greater ease, and whatever conduces to economy in this respect will ultimately make its way. In fact, it may be greater economy to burn half-a-dozen wax candles than one rushlight, six gas burners than the wax candles, and one electric light than the six gas burners The progression is not exact in one sense, but it will make our meaning clear. Of course we understand that the cost of the production of the electric light will approach more and more to the cost of gas. It is in connection with the electric light that the unspeakable ignorance of the daily press has shown itself. *The Times* has been first and foremost in spreading erroneous opinions, and of course is too wise to acknowledge its errors. Few people know the exact position of the electric light, its capabilities and its failings, and the voice of these few is utterly lost. Paris tried a light and found it wanting; we rush to try the same light, and hope to get a different result. Time will soon show that the change of soil makes little difference in these matters, and attention will then be directed to improvements which have been and are being made. Professor W. E. Ayrton has made a series of calculations which will prove of great service in all investigations relating to the electric light by incandescence. The following equation is his final result as to the current required:—

$$V = \frac{Q}{P}\left\{ 2\,\frac{\begin{matrix} -\frac{L}{2}\sqrt{P} & \frac{L}{2}\sqrt{P} \\ \epsilon & -\epsilon \end{matrix}}{\begin{matrix} L\sqrt{P} & -L\sqrt{P} \\ \epsilon & -\epsilon \end{matrix}} + 1 \right.;$$

which, for carbon, becomes $V = \frac{Q}{P}$.

The investigation from which this is taken will be given in our next issue. Mr. H. Wilde has just completed a system of electric lighting. M. Arnaud's system is, we hear, to be made public shortly; Mr. Harrison's will be ready in a few days. Mr. Sprague has turned his attention to improve generators of the current; and we know that others have been working in the same direction, and that machines quite equal to the Gramme can be produced at very considerably less cost. Mr. Edison's work in this direction is either good or bad. So far as it is known at present, viz., that the light is produced by the incandescence of a platino-iridium alloy, the consensus of scientific opinion is against it. Our idea of the future of the electric light may soon be told. The public experiments at present being made will be against its adoption; it will, perhaps, undergo a short eclipse, when its opponents will be jubilant, but it is, and it must be, a light to be utilised, and it will soon assert its superiority in various directions, and then gradually and surely extend its domain.

In telegraphy the chronicle is voluminous. Several instruments containing new features were shown at Paris, but it is impossible to describe them without illustrations, and therefore we must leave them to be dealt with elsewhere. Mr. Muirhead has pursued his course of success in duplexing cables, and, as stated in a recent number, he has during the past year added the "Direct United States Cable," and that portion of the Eastern Extension Company's between Penang and Madras to his achievements, giving a total of over 10,000 miles on which this system is worked. It was announced that Mr. Stearns had succeeded with the Atlantic cable, but his work was incomplete, and as yet we have not heard that he has satisfactorily completed it. Negotiations have been carried on for some time to connect the South African colonies by means of a cable with the Eastern Company's system at Aden, and it is possible we may have to state at a very early date that the whole scheme is complete, and that the work will proceed immediately. A good deal of influence has been exerted on behalf of a communication by means of land lines, but when tested by the stern realities of practice the scheme has failed to make headway. As we lately announced, the Australian Governments have agreed to grant a subsidy for the duplication of the cable connection with that continent. The work of manufacture of this cable and the laying of it will be commenced at once.

It may not be altogether out of place here to mention that the Ronald's Catalogue, which Mr. J. Frost has so ably compiled for the Society of Telegraph Engineers, will shortly be ready.

The following statistics for 1877 are taken from the *Journal Télégraphique*, published at Berne, 25th November, 1878. The distances are in kilometres, one kilometre being about ·62 of an English mile.

	Kil. of line.	Kil. of wire.	Offices.	Staff.
Bavaria has.....	7,947	33,465	993	480
Hungary	14,908	49,943	931	1,285
Belgium.....	5,174	22,569	636	1,844
Denmark	3,224	8,937	246	563
Spain	15,489	39,070	336	2,506
France	57,110	150,506	4,590	5,763
Norway	8,478	15,108	197	696
Persia.....	3,994	7,674	56	348
Portugal	3,711	8,042	167	810
Roumania	4,141	7,208	173	1,063
Russia	94,339	187,525	2,161	12,732
Sweden	10,740	27,809	676	780
Switzerland ...	6,506	15,926	1,080	1,626

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CORRESPONDENCE.

CABLE SIGNALLING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with great interest the letter of Richard Herring, Esq., on "Submarine Telegraphy," published in your paper of 21st ult. His treatment of the subject is purely scientific, and free from theory; and it is to be hoped that the obvious conclusions which he has drawn from the well-established facts in regard to the movements and effects of electric currents will lead to the utilisation of those facts, so that the *maximum* speed of transmission of signals through long submarine cables will be obtained; and thereby greatly increase their working capacity, and necessarily their profits, and perhaps justify the companies to reduce their tariffs.

Paragraph No. 16 of his letter gives the welcome information that he has a device to so utilize the well-established facts as to produce the great result, that is, the maximum speed of transmission.

It is sincerely to be wished that he is not deceived as to the practicability of his "device," and that he does not give to us hopes that may soon be disappointed, like many of those promises of the *great* and *modest American Inventor!!!* who announced in the newspapers that he had discovered the means to render noiseless the movement of trains of waggons on the elevated railroads in New York City, which noise, one of the New York newspapers with becoming gravity announced, was to be bottled up by the great discoverer, and to be sold to the Government to be used as fog whistles on the sea coasts. The facts stated by Mr. Herring are not theoretical deductions, but well established and uncontroverted facts, and there certainly cannot be any room for correction of his statements. The causes assigned for some of those facts, namely, for the differences of duration of charge, and of discharge, are purely *theoretical*, and may or may not be the true causes; nevertheless, the facts remain established.

It must be a matter of great astonishment that those facts, so well known, and upon which all the known systems of telegraphy are based, have not been applied in such a combination as to obtain the great result. The very fact that no such result has been obtained must suggest to everyone great doubts as to its practicability. The means capable of producing this result are so clearly demonstrated by those well known facts themselves that it really seems a wonder why no device to use these means has not long since been discovered; and the failure hitherto to make such a discovery almost forces upon the mind the conclusion that it is an impossibility. It may be, however, that science will show that this is not impossible, as it has so many other things which but a few years ago were deemed impossible.

While I will not presume to suggest even any correction of the statement of facts by Mr. Herring, I beg to submit a few remarks. In paragraph No. 14 Mr. Herring states:—

"When a conductor has received a charge of one kind of electricity, and is then put to earth at both ends, and also a charge of an opposite kind of electricity is sent into it from both ends, the conductor is restored to its neutral state in a duration of time not longer than that of the charge, whatever this latter duration may be."

This certainly is not a theory, but is a self-evident fact; but the great problem has been how to arrange to send at the proper time the opposite kind of electricity into the cable at the receiving end. That accomplished, the great result is obtained, and with impatience we await the promised disclosure of the device, and with sincere hopes that it may prove to be successful.

From reference in Mr. Herring's letter to "marks in special paper" I infer he employs on his receiving instrument paper saturated with some chemical solution. I believe that of all chemical solutions that of iodide of potassium is the most sensitive to the electric current, but its use has, I believe, been abandoned because of the evanescent quality of the marks. It would, no doubt, be a great *desideratum* if those marks could be made permanent as these signals sent through long cables, such as those crossing the Atlantic Ocean, could be recorded in Morse characters.

I may state, as an evidence of the great sensitiveness of iodide of potassium to the electric current, that I have been present when 200 words were perfectly recorded in Morse characters in one minute through a resistance of 37,730 ohms, with ten cells small size Leclanché battery. I have also seen 500 words recorded in one minute through 10,220 ohms with three cells of same size and kind. Perhaps some of your readers may know of some process by which the marks may be made less evanescent, or even permanent.

INQUIRER.

London, Dec. 30, 1878.

GOVERNMENT MONOPOLY AND INVENTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your article of the 21st December, animadverting upon the conduct of the Postal Telegraph authorities, who are virtually accused of smothering invention generally, and of wronging Mr. Herring in particular, it is stated that your only desire is to see justice done. Permit me, therefore, to help your readers to do justice to all the parties concerned. It should be remembered—firstly, that the persons assailed cannot defend themselves. The instance you cite to the contrary appears to me to be no exception to the rule. An American paper, of high standing, draws certain hasty conclusions, which reflect upon this country's telegraphic reputation; and a gentleman who thoroughly well knows our true position, and who happens to be a postal official, points out the fallacy upon which those conclusions were based. This much, any public official may do; but a public Department, as such, cannot speak for itself. Complaints from disappointed inventors, and self-satisfied criticisms from foreign sources should be accepted with extreme caution. I would remind your readers also that the telegraph administrations of this country, whether commercial, railway, or Governmental, are all open to inspection. Any adverse comparisons which emanate from quarters either too indolent, too timid, or too far away to inspect what they presume to undervalue cannot be worth very much. The gentleman just referred to says, in effect, that the Postal Telegraph system, for example, can hold its own against any system in the world. Now, if this is not true, it can be easily confuted. If it is true, it accounts for much disappointment among would-be inventors; and unless we expect the country to purchase every novelty, merely because it is novel, much of the fault-finding would appear to be groundless.

Giving these circumstances their due weight, I think we may arrive at conclusions different, in some respects, from those suggested in your leader, and the very reverse of those urged upon us by Mr. Herring. We can form a tolerably correct opinion upon his case from his pamphlet, entitled "Vis Inertiæ at the Post Office" (Longmans), and from what has recently appeared in this journal. But, taking his invention at his own estimate, it deserves to be numbered among the outcomes of British ingenuity; and, if he were in America, the fact that it, and a hundred such, might be useless, would not prevent it swelling the roll for that country. In England, however, the custom has been—and was so before the Post Office took over the telegraphs—to damn a failure and say no more about it. The exceptional feature about the Herring instrument is that the condemnation, although prompt and emphatic enough for ordinary mortals, was not sufficiently so for Mr. Herring. He tells his own story, and the conclusion to be drawn from it by everybody but himself is that he has had a great deal *more* than justice. Having some considerable experience of inventions and among inventors, I make bold to say that the line he has pursued throughout has done more harm to outsiders generally than any amount of *vis inertiæ* in public departments could have inflicted. The example he has set is enough to frighten all reasonable men outside, and disgust every official inside departmental boundaries. Availing himself of circumstances, in which we can well imagine the Post Office was placed at that time, he forced upon their notice an invention which the best judges declined to recommend; he put them to enormous expense; and he knew all the while that his instrument could not beat the appliances in use, and that in several respects it was inferior to them. How he managed to obtain so many concessions, the use of clerks, the appropriation of lines, the construction of instruments, the paying of referees, we can only guess at. But it is certain that no man ever had so much indulgence at the hands of a Government office, and certainly not from any private company. Inventors would be glad to be "smothered" in that way a little oftener. But Mr. Herring was insatiable. If the Herring instrument was not adapted to British lines, then the British lines must be adapted to the instrument. If it would not accurately record the unequal signalling of fast speed operators, the operators were to be moulded to Herring's convenience. If it was as good in *any* respects as existing apliances, then they must be displaced to make room for it. Not content with disputing their decision, he roundly accuses the referees (Sir Wm. Thomson and Mr. Fleming Jenkin) of going through a preconcerted farce of a trial and delivering a partial verdict. He sneers at Mr. Culley, and insinuates that he made a dead set against the invention from sheer perversity. He likens Mr. Scudamore to an "impatient boy"—the boy in question, if we may judge from the correspondence, being about the best-tempered and most open-handed gentleman that ever inventor had to deal with. More than this, Mr. Herring says he got a sight of the private official documents; and the use he makes of them, apparently, is to take appropriate extracts to back up his case and publish them in a pamphlet! He lays hold of every

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mention of a merit as proof of the substantial value of his instrument, and perverts every generous concession into an admission of his claims. Anybody who is practically qualified to understand it will arise from the perusal of the final award of the referees (which I fear is too long for you to reprint) with a conviction that it errs rather on the side of leniency. The instrument never was and never can be wanted; and if its inventor has anything to lament over, it is that it was not summarily thrown out in the first instance. But he cannot make even that a ground of complaint against the Post Office, because it is plain to be seen that he would not be denied.

One word about Mr. Herring's outstanding claim to have a fresh trial. The matter is a little obscure, but as far as one can make out from the pamphlet it is based upon a supposed admission of his *right* to have a new trial because one of the referees said that no trial could be complete without eliminating the faults of hand manipulation; which is true enough as a question of abstract completeness, but seeing that the instrument could not even then, much less now, compete with automatic senders, its trial upon automatic circuits could serve no practical purpose.

I am surprised to see it stated that Mr. Herring's grievance is "not denied." That depends upon what is meant by grievance. Mr. Preece despairingly admits that it is hopeless to deny anything that the irrepressible Mr. Herring chooses to assert. But the denial of his claim upon the Post Office, of the utility of his invention, and of his right to ask further concessions, is clear and emphatic from the very commencement.

On the whole, therefore, I venture to believe that a case against the Government authorities is not made out by this alleged instance of smothering. And, as to the facts adduced from America in support of the contention that England is behind hand in telegraphic invention, they cannot in fairness be charged to the fault of the several telegraph administrations here. We might as well blame them for our not having invented the sewing machine. What we have to look at are results; and unless it can be shown that the telegraphs of this country are (1) behind those of other countries, and (2) decline to introduce practical improvements, it really cannot signify whether a few patents more or less are taken out on this side of the Atlantic, or on the other.
—Yours truly, FAIR PLAY.

A SUPERANNUATION FUND.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I, for one, and I feel sure many others have been long and anxiously on the look-out for something further on this subject, which is of the greatest importance to all those in telegraphic service abroad.

In your issues of 24th and 31st August, you said that two of the most important companies had the matter of a Superannuation Fund under consideration. The fact is, we have been expecting to hear something from the companies as to what form the Fund should take.

There is no doubt that all, or nearly all the *employés*, would gladly join could they see their way clear to do so.

We, in these out-of-the-way places, have small opportunity of knowing much about such matters; it would, therefore, be very difficult for many of us to draw out a scheme for the working of such a Fund. I think if some one in London (where all the data for this sort of thing is at hand) would draw out a plan and publish it in your valuable journal, we could con it over, and, perhaps, make some suggestions which would assist the matter on.

I look upon it as of the greatest importance to all, and especially to those who have spent the best years of their life in an eastern climate; let that climate be never so good, we do not look forward to ending our days in it, and naturally wish to spend the last years in the old country. Without a pension there is no chance of this; the pay we get will not allow of saving much—indeed, not enough to provide for the rainy day which, in the ordinary course, we must all expect, sooner or later, to overtake us. There are a good many old telegraphers in the great cable companies, some of nearly thirty years' standing, who would, I have no doubt, be glad to pay up subscriptions, with interest, for any number of years that may be decided upon. I believe the companies themselves will benefit just as much as the *employés*, the men having something to look forward to in the future, the bond between them and the companies will be strengthened, besides raising telegraphic service in the social scale.

I am of opinion that, when once started, subscription to the Fund should be made compulsory on all new comers; in fact, to form one of "the conditions of service."—I am, sir, your obedient servant, ES. SUS.

Dec. 18, 1878.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Before anything can be done in the way of organising a Superannuation Fund, it is absolutely necessary that the views of the directors of the several submarine companies be obtained. However willing men stationed abroad may be to take the matter in hand (and I am sure many are willing), it is impossible for them to do so until those views are known.

I would, therefore, beg you to allow me, through your paper, to appeal to the London staffs of the various companies to hold a meeting, and depute a certain number of their body to wait upon the directors requesting their opinions, and, if possible, to ascertain how far the different companies are willing to assist an association formed for such a laudable purpose.

This very necessary preliminary attended to, committees at foreign stations could at once be arranged and organisation commenced.

You, Sir, I believe, would allow the deputation to communicate the result of their labours to the staffs abroad through your columns.

In my opinion the provisions of the Fund, to be most beneficial to all concerned, must follow closely on the lines of those of the Railway Clearing House, as quoted in your leader of Aug. 31.

Trusting to hear soon that some definite steps have been taken,
—I remain, yours truly, ONE INTERESTED.

Dec. 28, 1878.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am daily more convinced that the telegraphist of the present day is as indifferent as ever as to his future, he is still, the happy-go-lucky sort of man that has distinguished the English telegraph operator for many years, and I think the knowledge of having nothing to look forward to may be considered the principal cause of his apathy.

This, sir, ought not to continue. At this enlightened period of the nineteenth century, one would have hoped that every telegraph clerk would have given such a decided opinion on the subject of the "Superannuation Fund" that nothing could have stopped its consummation; even yet, Mr. Editor, I have every hope that the project will still be carried out.

A man ought, at least, to consider his own future, and that of his family very seriously, and no great amount of foresight is necessary to put it in its proper light. Is there a man amongst us who can seriously and conscientiously say, "*What do I care for my future?*" none of us would like to find ourselves unfit for work without having made some provision. To see one's wife or little ones brought to poverty through our own negligence, would cause a remorse so great that very few would be able to bear its sting.

The formation of this Fund would, I consider, be a benefit to our employers as well as to ourselves. Any man labouring with the knowledge of having a haven of rest before him, would be able to work with a much lighter heart and clearer brain, both of which are necessary for a telegraph clerk to do his work *well*.

Make his future something more than a myth, and he will stick to the service. I have known many promising clerks to resign, merely because they were not satisfied about the future.

Let us with the new year commence in earnest to make the fund a reality; whilst we are thinking over it, very valuable time is being lost, it can and must be done. Firstly, we want one of the large companies to come forward and offer to receive propositions from all their stations as to the advisability of it, and as to the best means of carrying it out.

When that is done the rest is very easy. Who will be the first to offer the largest boon that ever could be offered to English telegraphists?—Yours truly, ONE OF THEM.

Dec. 18, 1878.

MEASUREMENT OF CURRENT IN ABSOLUTE UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think Mr. Sprague will find there is an error as to the constant of the second formula given by him at the bottom of col. 1, p. 69.

We have here the equation

$$1{\cdot}764\frac{r^2}{L} = {\cdot}5615\frac{d}{n};$$

but $r = \frac{d}{2}$ and $r^2 = \frac{d^1}{4}$; and the length of the coil must necessarily be $L = d\pi n$. Thus $\frac{r^2}{L} = \frac{\frac{d^2}{4}}{d\pi n} = \frac{d}{4\pi n}$. We have, therefore,

$$C = 1{\cdot}764\frac{d}{4\pi n}\tan.\theta.$$

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And, since $4\pi = 12{\cdot}566$, and $\frac{1{\cdot}764}{12{\cdot}566} = {\cdot}14$, the second formula should be

$$C = {\cdot}14 \frac{d}{n} \tan.\theta \ (Abs.\text{-}M.\text{-}G.\text{-}S.\ units). \quad . \quad . \quad (I.)$$

For B.A. units this formula becomes

$$C = 14 \frac{d}{n} \tan.\theta \ (vebers\ per\ sec). \quad . \quad . \quad (II.)$$

The value of H, for the present year, is, however, not exactly 1·764, but 1·795 Abs.-M.-G.-S. units. Thus the constants are, more accurately, ·143 (in I.) and 14·3 (in II.).—I am, &c.,

DESMOND G. FITZGERALD.

A SIMPLE ELECTRIC PEN.

By WENTWORTH LASCELLES SCOTT, A.S.T.E., Lecturer on Chemistry and Physics to the London Conservatoire of Music, &c.

The electric pen recently introduced into this country has several disadvantages which are calculated to militate against its general use. As a "scientific toy" and compact electromotor it will doubtless fill a small place amongst the "novelties" for a time, but the heaviness and awkwardness of the "pen" itself, the large size and power of the battery needed, and above all, perhaps, the very high price (8*l.* 8s.) at which the apparatus is offered to the public, are sufficient to keep it out of most offices, and almost to prohibit its use in private families.

The little contrivance which forms the subject of the present article could be sold at a good profit for from 25s. to 30s. complete, or can be put together by any one possessing a very moderate amount of electro-mechanical skill at even less cost than the former sum, while the "pen" *per se* is as convenient and as light to hold as an ordinary pencil, and can be actuated by a comparatively very small single-cell battery.

The accompanying rough sketch needs but little explanation, and shows fairly well the arrangement devised and actually used by me.

A is a Daniell's cell of medium size, which is all the battery power required; indeed, a very small bichromate or "Marié-Davy" couple may often be substituted here, where the pen is not required for very hard and continuous use. The battery connected in the usual way to the primary terminals of a small induction coil B, and for this purpose one of the little coils generally

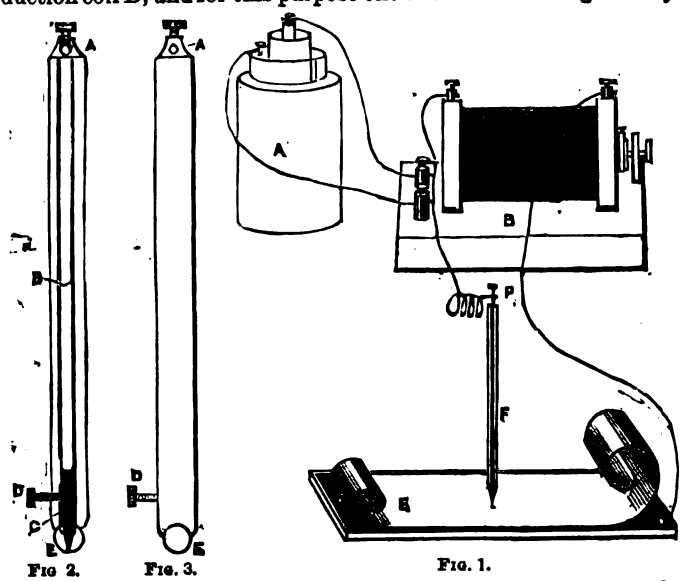

FIG 2. FIG. 3. FIG. 1.

accompanying the cheap French sets of apparatus for "vacuum-tube experiments," answers very well if certain simple improvements be applied thereto. As a rule these tiny "Rhumkorffs" give a secondary spark of from ¼in. to 3-16in. in length, but would give a much longer one only that the vibrating armature is not sufficiently delicate, while the condenser is often only a delusion and a snare. The former should be more delicately adjusted, a really elastic bit of spring being added if necessary, and the latter should be taken out and replaced by a sound and practical condenser, containing 300 or 350 square inches of tin foil, carefully insulated with paraffin paper. When these alterations are completed, it will be found that the spark is increased in length to some 5-16in., or even more.

The desk or writing slab consists of a plate of glass or vulcanite of suitable dimensions, upon which has been evenly laid a perfectly smooth, but rather smaller sheet of silver or tin foil D, the whole being protected from damp by a coat of thin amber varnish; at one corner of the slab is fixed a binding-screw E, in contact with the metallic surface, and connected by a wire with one terminal of the secondary coil.

The writing stylus or "pen" F consists of an ivory or vulcanite tube pointed at its lower extremity, and provided at the other end with a small brass terminal; from the latter a stiff wire, furnished with an extremely fine platinum point *(p)* proceeds in the interior of the tube, and is capable of adjustment by a small set-screw. In practice this platinum point should be (when the stylus is turned up) *very slightly* below the level of the aperture in the ivory. The "pen" being then connected to the free terminal of the secondary, and the little coil set so that the primary sparks appear almost continuous by reason of their very rapid succession, a sheet of paper laid upon the slab C will be quickly perforated in a series of minute holes if the point of the stylus be gently drawn over it.

Any writing, plan, or outline drawing, may be traced in this way upon the paper, although in a somewhat slower manner than with an ordinary pen. When removed from the slab the paper is found to be a kind of stencil-plate from which, by laying in succession upon a number of sheets of paper, and applying the ink roller or "dubber," many hundred fac simile copies may easily and quickly be obtained.

If an "electro-stencil" of a large architectural or other plan or of a map be wanted, a slightly modified stylus will facilitate the work. Fig. 2 shows such an instrument drawn to scale (half the original size), fig. 3 being a section of the same. A represents the terminal for the reception of wire from coil. B is a brass tube extending to within an inch of the "writing," or lower end of the stylus, where it receives a pointed platinum wire C, which can be fixed at any required height by means of the set screw D. A small ivory wheel E enables the stylus to travel easily and evenly over any long continuous lines, either with or without the aid of a ruler.

Other applications of this simple and easily-constructed electric pen will suggest themselves to the intelligent reader, and it may readily be made (if really needed) far more rapid in its action than the costly instrument before alluded to. Its use infringes no patent, as its action depends upon well known principles, which have even been applied somewhat in the same way for lecture demonstrations before now, and it offers to the readers of *The Electrician* a practical and effective "multigraph" at a comparatively insignificant cost.

THE QUESTION OF TRANSATLANTIC CABLES.*

The creation of new lines of cable to connect France with the United States has caused a certain feeling in England, and has led to a discussion, of which our London correspondent transmits us a *resumé*. We extract the most important passages and those which appear to be most in accord with the long and costly experience acquired by our neighbours :—

"The Stock Exchange," says our correspondent, "learned with some surprise that there was a question of constituting a Parisian Syndicate for the purpose of raising sufficient capital to cover the expense of establishing one or more cables between France and America. But this report was speedily denied, and it was known before long that all the truth in the rumour consists in the fact that English manufacturers were again in the field at Paris to promote a new scheme. The loss suffered by the Syndicate of the 'Direct' Cable in England having exceeded 500,000*l.* sterling, of which a large part was borne by some of the Paris establishments, one is a little astonished at the boldness of English constructors and their agents in seeking to tempt Paris houses once more by a project which the London Exchange, enlightened by the sad experience of the past, considers absolutely folly.

"When the subscription for the Direct Cable was opened in England the public had the wisdom to take only 3,000 shares out of 65,000 offered, and the enormous loss suffered at length by the Syndicate, which had to absorb the remainder, has well proved how far the English public correctly judged the risk of the enterprise. One may say, in fact, that from its commencement the history of this cable has been a continuation of disappointments and disagreeable surprises, owing to the accidents during the laying of the cable, to the war of tariffs commenced by the rival undertaking—the Anglo-American Company—and the depreciation of the price of the shares, which from 20*l.*

* Translated from the Paris *Soir*, of Dec. 27, 1878.

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has gradually declined to about 7*l*., and even 6*l*. The fact is that only a small number of the original shareholders have had the courage and patience to remain in the concern, and it may be said that the anxiety of the proprietors only really disappeared when the two companies decided upon a fusion of their receipts, which was only effected after enormous difficulties between the rival companies, and which gave the 'Direct' Line a real guarantee of four cables, and a continuation of revenue in the event of interruption.

"Nevertheless, in spite of the advantages of this fusion, by means of which the 'Direct' Cable receives a quarter of the total Atlantic receipts—this being fully equivalent to the proportion of the messages transmitted by that line—the shares of the Direct Company at this moment are only worth about 12*l*., instead of 20*l*., their nominal value.

"One is more and more convinced, indeed, that the position of a company possessing only one cable, and, above all, one Atlantic cable, with the immense risks attached to it, is most precarious, and even two united cables barely offer the security which a prudent shareholder should require. A real guarantee can only be given by a larger number of cables to provide against all sorts of dangers. We may say that the 'Direct' Line has already been interrupted several times, and the Brest cable more than twelve times. What would have become of their revenue without the guarantee of the other lines which continued to work?

"Since the first cables of 1865 and 1866 were abandoned as lost and worn out, the willingness of the British public to put money in cables has considerably cooled, and a general conviction has spread that a Cable Company only offers a real security when it possesses several lines, and this applies above all to Atlantic cables.

"Then the four existing cables have a transmitting capacity three or four times superior to the exigencies of the actual service, and the tariff receipts at 3s. per word, which rate certainly cannot be raised, are hardly sufficient to pay 5 or 6 per cent. dividend, after deducting the necessary reserve for the construction of a new cable in case of need.

"One asks if even the promise of larger commissions, the inducement offered by the manufacturers to the Syndicate, can make new victims? For it is necessary to say that, if the English public, notwithstanding all its boldness and experience of business, will have no more of these shares, the French people, more cautious, and, in this sense, perhaps, more intelligent, would certainly not wish to do so.

"It is also necessary to add that this new cable project brought forward in Paris, even with the inducement of high commissions, presents no serious chance of success.

"Nevertheless, these rumours of a new combination for establishing trans-Atlantic cables frequently re-appear. In France it is affirmed that England will provide the money, while in England it is the French public which is reputed to have assured the funds.

"It is very certain that our financiers will not longer suffer themselves to be enticed into making combinations, profitable only to the contractors, by commissions taken out of their own pockets; because a short struggle between the rival cables and a passing war of tariffs are of no true service to the public. This invariably ends in an understanding between the companies, and those who have invested their money withdraw, exhausted by a barren struggle, and with a loss of both time and capital."

THE ELECTRIC LIGHT.*

By W. H. PREECE, Memb.Inst.C.E., V.P.Soc.T.E., Electrician General Post Office, &c.

1. The theory of the electric light cannot be brought absolutely within the domain of quantitative mathematics, for the reason that we do not yet know the exact relation that exists between the production of heat and the emission of light with a given current; but we know sufficient to predicate that what is true for the production of heat is equally true for the production of light beyond certain limits.

The work done in a battery, or any source of current-electricity, is expended outside the battery in a closed circuit in the form of heat. When this heat acquires a certain temperature per unit mass, we have light. If the heat be confined to a mass of metal wire like platinum, we have light by *incandescence*; if it be expended in the transference of minute particles of incandescent matter like carbon across an air-space, we have the *electric arc*. The exact relations between current, heat, temperature, mass, and light have yet to be determined by experiment.

2. The arc is thus a form of energy developed in one point of a circuit, which is the exact equivalent of another form of energy expended in another point of the circuit. Thus, if we produce light by a galvanic battery, it is the equivalent of chemical work done in the battery. If it be produced by a dynamo-machine driven by a steam-engine, it is the equivalent of coal consumed in the furnace. The object to be attained in any economical utilisation of this energy is to convert the greatest possible portion of it into light.

3. Now the relations that exist between the work done, the current flowing, the resistances present, and the heat developed are easily demonstrated. The work done (W) in any circuit varies directly with the electromotive force (E) in that circuit, and with the quantity of electricity (Q) that passes through it, or $W = E Q$; but by Ohm's law the electromotive force is equal to the product of the resistance (R) of the circuit into the current (C) flowing, or $E = C R$; and by Faraday's law the quantity of electricity passing depends upon the strength of current (C) and the time it flows (t), or $Q = C t$. Therefore, substituting these two values in the above equation, we get $W = C^2 R t$; in which we have what is known as Joule's law, which gives us the work done (W), or its equivalent, the heat generated (H) in any circuit. By regarding the time as constant, we can put the equation

$$H = C^2 R. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

4. Now let us take the case of a battery whose electromotive force is E, and whose internal resistance is ρ. Let the resistance of the connecting wires be r. Let us also have a particular resistance l, which may be a wire to be heated to incandescence, or a lamp to be lit by the arc; then by Joule's law (1), $H = C^2(\rho + r + l)$; but, by Ohm's law, $C = \frac{E}{\rho + r + l}$.

$$\therefore H = \frac{E^2}{\rho + r + l}.$$

5. Confining our attention for the present to the heat generated (H), this will be distributed throughout the circuit; and that in the resistance (l) will be

$$H \times \frac{l}{\rho + r + l} = \frac{E^2 l}{(\rho + r + l)^2}. \quad . \quad . \quad . \quad . \quad (2)$$

Now if we suppose n resistances in circuit joined up in *series*, then the total heat generated will be

$$H' = \frac{E^2 n l}{(\rho + r + n l)^2}. \quad . \quad . \quad . \quad . \quad . \quad (3)$$

If we differentiate this fraction with respect to $n l$ and put it equal to nothing, we can find when the heat generated in these resistances becomes a maximum; that is,

$$\frac{d H'}{d n l} = \frac{1}{(\rho + r + n l)^4}[(\rho + r + n l)^2 E^2 - 2 E^2 n l (\rho + r + n l)] = 0,$$

whence $\rho + r + n l = 2 n l$; that is, $\rho + r = n l$; or *the greatest heat is generated in the resistances when the value of the latter equals the resistances of the rest of the circuit.*

(TO BE CONTINUED.)

* Communicated by the Author to the *Phil. Mag.*, Jan., 1879.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES Dec. 31.		BUSINESS DONE WEEK ENDING Dec. 31. Highest.	Lowest.
Anglo-American	57¼,	8	57¼	56¼
Do. "B"	83½,	¼	84	83
Do. "A"	32½,	3	33	31½
Brazilian ex div.	6¾,	¼	6¾	6¾
Cuba	8½,	¼	—	—
Do. Ten per Cent. Preference	15,	½	15	—
Direct Spanish	1¾,	2¼	—	—
Do. Ten per Cent. Preference	9½,	10	9¾	—
Direct United States	11¾,	¼	11¾	11¾
Eastern	7¼,	⅛	7 5-16	7¼
Do. Six per Cent. Debenture	102,	5	103¾	—
Do. Five per Cent. do.	100,	3	—	—
Do. Six per Cent. Preference	10¾,	11¼	11¼	10¾
Eastern Extension	7 1-16,	3-16	7¼	7 1-16
Do. Six per Cent. Debenture	103,	6	—	—
German Union	8,	¼	—	—
Globe Telegraph and Trust	4¾,	5	4 15-16	¼
Do. Six per Cent. Preference	10½,	⅛	10¾	—
Great Northern ex div.	7½,	¼	—	—
Indo-European	19,	20	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	8½,	9¼	—	—
Reuter's	9½,	10¼	—	—
Submarine	215,	20	—	—
West India and Panama	1¾,	2	—	—
Do. Six per Cent. Preference	7¾,	8¼	—	—
Western and Brazilian	2½,	⅛	—	—
West. Union Seven per Cent. 1st Mort.	114,	18	—	—
Do. Six per Cent. Sterling	100,	2	—	—

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NOTES.

GREAT NORTHERN TELEGRAPH.—The company have declared a dividend for the past half year at the rate of 5 per cent. per annum.

WESTERN UNION TELEGRAPH.—The company have declared a quarterly dividend at the rate of 6 per cent. per annum, carrying forward 254,141 dollars.

EASTERN EXTENSION COMPANY.—The Batavian section of this company's cable is now in working order, and messages can be sent through to Australia.

THE DIRECT UNITED STATES CABLE.—A defect has appeared in this cable near the shore at Torbay, delaying the transmission of messages, which, until the fault is removed, will be forwarded by the Anglo route.

CUBA SUBMARINE COMPANY.—The number of messages passing over the lines during the month of December was 2,580, estimated to produce 2,800*l.* against 2,241 messages, producing 2,666*l.* in the corresponding month of last year.

ATLANTIC AND PACIFIC TELEGRAPH.—Advices from New York state that the company, which has now pooling arrangements with the Western Union Telegraph Company, has declared a quarterly dividend at the rate of 3 per cent. per annum, carrying forward about 65,000 dollars.

THE TELEGRAPH IN GUATEMALA.—The telegraph extends all over Guatemala, and messages of ten words, exclusive of date, address, and signature, can be sent any distance within the limits of the Republic for 1*s*. The lines belong to the Government, and are under the direction of Mr. Stanley McNider, an Englishman, who is justly praised for the excellence of the service.

MR. EDISON AN AUTHOR.—Mr. Edison has completed arrangements with Messrs. Sampson Low and Co. and Messrs. Harper Brothers for the simultaneous publication in both England and the United States of his new work on the electric light, mentioned in our last number. The work has already been commenced, but, owing to the peculiar condition of affairs as regards patent applications, the time of its completion cannot at present be definitely stated.—*Athenæum.*

THE ELECTRIC LIGHT PUT OUT.—In America, says the *Engineering and Mining Journal*, several manufacturers who had introduced the electric light into their works, have withdrawn it, owing to the intermittent character of the light used, which it seems injuriously affected the optic nerves of the workmen. We opine that such intermittency should have been obviated, and the direct glare of the light shaded from the workmen. It is admitted that the intermission is not infrequently due to the engine being employed for other work as well, and hence not giving constant revolutions.

COLOUR OF THE ELECTRIC LIGHT.—By the combination of the suitable chemicals during the manufacture of the carbons, or by saturation afterwards almost any coloured tint may be obtained. The natural violet rays are neutralised by the addition of a few grains in each carbon of chloride of sodium, producing a yellow tint like the sunlight. Magnesia produces a very white light, and is well adapted to photography. A mixture of arsenic, on the contrary, produces a light almost devoid of chemical effect. Various proto-salts and sulphates of the metals may be so combined as to produce almost any desired colour.

THE ELECTRIC LIGHT.—Mr. Louis Schwendler, superintendent electrician of the Government of India, who has been on special duty in England, has addressed a communication, under date November 1, to the board of directors of the East Indian Railway Company, informing them that the results obtained from experiments leave a considerable balance of evidence in favour of the introduction of the electric light in Indian railway stations. He therefore recommends a practical trial of the electric light, either at Allahabad or at Howrah stations. Dynamo-electric machine A (supplied by Messrs. Siemens Brothers; construction, Siemens; system, Hefner von Alteneck) was found the most efficient of the four under trial. He recommends its adoption, with such alterations as his own experiments have suggested. Of the lamps tried the Serrin lamp was found the most practical, and he recommends its adoption, with certain alterations. An abstract of the report will be given next week.

DIVISION OF THE ELECTRIC LIGHT.—The mode in which this is effected is by parting a large wire into numerous branches, each branch of the same length and conducting power, and receiving an equal proportion of the current. The branches are further subdivided, and the supply of the lateral stems similarly regulated. In practice, Mr. Edison will make use of two large main wires of copper, one for the outflow of the current from the machines, the other for its return. The mains will not be united at the outer ends. The positive wires will throw out a branch into each building it passes which takes the electric light. This branch will return to the negative main, thus completing the circuit. It is expected that the current can thus be sudivided any number of times. The mains are to be supplied with a deluge of electricity, if the expression may be allowed, generated by magnetic machines, built for quantity and not for intensity, and it is expected that each building will receive its proportional share of the current. A subdivision of the current has been patented, by which the lights are placed in branch circuits, running across from the positive to the negative conductor; any number which the machine will support may be used and governed by switches.

ELECTRICITY AND LIGHTNING.—Mr. Stephen Grey, a Charterhouse pensioner, who discovered the difference between conductors and non-conductors, and other capital facts, appears also to have been the first electrician who entertained the notion of an identity between electricity and lightning. In the concluding paragraph of one of Mr. Grey's papers printed in the "Transactions of the Royal Society," the author says, whilst contemplating the results of the experiments he had been describing in the same paper:—"By these experiments we see, that an actual flame of fire, with an explosion, and an ebullition of cold water, may be produced by communicative electricity (communicated to a metallic rod, an iron ball, and other bodies, on which he had been experimenting); and though these effects are at present but in

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minimus, it is probable that in time there may be found out a method to collect a greater quantity of it, and, consequently, to increase the force of this electric fire, which, by several of these experiments, seems to be of the same nature with that of thunder and lightning." These predictions, which were printed in "Transactions for the Year 1735," ten years prior to the discovery of the Leyden Jar, and about seventeen before the first successful experiments on atmospherical electricity, were wonderfully verified in these two memorable events.

USE OF THE ELECTRIC LIGHT IN A BRISTOL FACTORY.—The firm of Messrs. W. D. and H. O. Wills, the well-known manufacturers of the universally-celebrated "Bristol Bird's Eye," have just had fitted up, under the supervision of Dr. Thompson, of the Bristol University College, one of the American Wallace-Farmer machines for supplying the electric light in their central manufactory in Redcliff-street. The "armature" of the Wallace-Farmer machine consists of a number of bobbins arranged round the circumference of a wheel, and these rotate at a speed of about 500 revolutions per minute between the poles of a powerful electro-magnet, which is joined up in the same circuit. This generates the current of electricity, which is carried round the extensive factory by cables that traverse the several rooms, so that, by severing the cables in any room and attaching the two ends to a Wallace lamp, as many as ten electric lights can be obtained in as many departments of the establishment. Special attention has been devoted to the application of the electric light to the "leaf" room, where the tobaccos when turned out from the hogsheads in their imported condition have to be sorted with the most delicate care, in order to get the very finest and ripest leaf for the choicest brands of the firm. In the sorting the workpeople are guided chiefly by the colour of the leaves, the tobacco of one growth in a single hogshead varying so greatly that every portion of it has to be most carefully assorted. This can be done by daylight with ease in rooms specially adapted, as are those of Messrs. Wills, for this purpose. But the operation becomes difficult in the winter, after four o'clock, by the light of ordinary gas, which fails to bring out the true colours of the leaves. The electric light, however, is found to supply all that is wanted. The lamp used was only temporarily arranged by Dr. Thompson, those to be permanently supplied not having arrived. Instead of having simply carbon points, the Wallace lamp is formed of carbon plates, some of ten inches in length, and adjusted with such delicacy that when in use they will burn for 100 hours without replenishing, and the whole time they are in operation they are by a mechanical arrangement self-adjusting. In order to soften the light and make it more diffused the lamps will be encircled with opal. The machine is at present driven by the ordinary engine which drives the rest of the machinery at the Redcliff-street factory, and it is one of only a few that have yet been erected in this country.

SPECIFIC INDUCTIVE CAPACITIES OF CERTAIN DIELECTRICS.—On p. 37, Vol. I, will be found a Note on this subject, being the abstract of a paper by Mr. J. E. H. Gordon, presented to the Royal Society. The results of this paper have been found to be incorrect, and in a revised paper presented to the Royal Society Mr. Gordon says:—In the course of the summer it was pointed out to me that owing to a mistake in the formula of calculation all the results were wrong. I, therefore, requested permission to withdraw my paper, in order to recalculate the results. The new values of K arrived at led me to make some determinations of refractive indices and to rewrite the theoretical deductions at the close of the paper. I now beg, through Professor Maxwell, to present the paper in an amended form, in the hope that it may be found not entirely unworthy of the attention of the Royal Society. As it would be impossible within the limits of an abstract to give any intelligible account of the new method of experiment (due to Professor Maxwell) which has been employed, I will merely give the table of results, reserving all discussion and explanation until the publication of my paper in full. I may, however, state that the method is a zero method, that the electrified metal plates never touch the dielectrics, and that the electrification, which is produced by an induction coil, has an electromotive force equal to that of about 2,050 chloride of silver cells, and is reversed some 12,000 times per second.

Dielectric.	*Results.*		K.
Glass, Slabs about 1 inch thick. Chance's optical glass.	Double extra dense flint		3·1639
	Extra dense flint		3·0536
	Light flint		3·0129
	Hard crown		3·1079
Common plate, 2 slabs.	No. 1	3·2581	3·2431
	No. 2	3·2282	
Ebonite, 4 slabs, ¾, ½, ½, ¼ inch.	No. 1	2·2697	2·2838
	No. 2	2·2482	
	No. 3	2·3097	
	No. 4	2·3087	
Best quality gutta percha			2·4625
Chatterton's compound			2·5474
India-rubber	black		2·2200
	vulcanised		2·4969
Solid paraffin, sp. gr. at 11°C. ·9109. Melting point 68°C. 6 slabs cut in planing machine. Results corrected for cavities.	No. 1	1·9940	Mean ... 1·9936*
	No. 2	1·9784	
	No. 3	1·9969	
	No. 4	2·0126	
	No. 5	1·9654	
	No. 6	2·0143	
Shellac			2·7464
Sulphur			2·5793
Bisulphide of carbon			1·8096†

The following table compares the refractive indices of the transparent dielectrics with the square roots of the specific inductive capacities. In cases where there is a wide difference μ is taken from books on physics; wherever there was a close agreement it was carefully determined by the author, except in the case of paraffin, where the value is that given in Maxwell's "Electricity:"—

Dielectric.	$\sqrt{K}$	Nearest value of μ.	Ray for which μ is nearest.
Double extra dense flint glass	1·7783	1·7460	Band in extreme violet in magnesium spark spectrum.
Extra dense flint...	1·7474	1·6757	
Light flint.....	1·7343	1·5113	
Hard crown	1·7629	1·5920	
Plate glass.....	1·8009	1·543	
Paraffin	1·4119	1·422	Rays of infinite wave length.
Sulphur	1·6060	2·115	
Bisulphide of carbon	1·3456	1·6114	

* Messrs. Gibson and Barclay, "Phil. Trans.," 1871, using a method entirely different from mine, obtained K=1·977 for paraffin. Correcting for a slight difference of density, I find that if they had used my paraffin their result would have been 1·9833.

† I am not quite certain of the accuracy of this result.

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ELECTRIC LIGHTING.

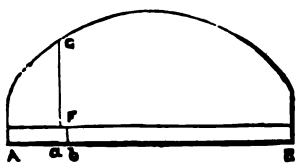
To determine the Electromotive Force required to maintain a rod of a given material, of given dimensions, at a given temperature, when loss of heat by radiation, convection, and conduction are taken into account.

BY PROF. W. E. AYRTON.

Having found it necessary to solve the above question in connection with the possibility of economically illuminating, by a material rendered incandescent with the electric arc (the system employed by Edison, Werdermann, Sawyer-Man, &c., and *first* patented in England by *De Moleyns* in 1841, and not, as commonly supposed, by *King*, since his patent bears the date of 1845), I have thought that the results obtained may be generally interesting.

The problem of the flow of heat through a bar from which there is loss of heat by radiation and convection has, since the time of Fourier, been often treated; the mathematical investigation was employed by Forbes in his experiments made to determine whether the heat conductivity of iron, like the electric conductivity, varied with the temperature, and exactly similar equations have been made use of in studying the passage of an electric current through a wire from all points of which there is leakage, as in an ordinary submarine cable, and especially in a submarine cable made of inferior gutta-percha. The problem, however, we have on the present occasion to deal with differs from the preceding in that we have, at every point, not only loss of heat by conduction, radiation, and convection, but, in addition, a generation of heat due to the resistance opposed to the passage of the electric current. This, however, as will be seen, adds little difficulty to the problem.

Let A B represent the wire through which the electric current is flowing, and let ordinates be drawn representing the temperature at each point—for example, let F G represent the temperature at the point F. Then drawing a temperature curve, we obtain a line something like A G B. The curve may, since heat is generated in the bar, be everywhere concave to A B, and not convex, as is the case if it were merely flowing along and dissipated by radiation. The exact shape, however, of this curve will depend on the conductivity, surface emissivity of the bar, and the amount of heat generated at each point. Let C be the electric current flowing through it, let ρ be the specific resistance (or resistance per cubic centimetre), let the bar be round and of radius r centimetres, then the amount of heat generated in a length dl is, per second, $\frac{C^2 \rho\, dl}{J \pi r^2}$; where, if C and ρ are in absolute electro-magnetic units (gramme, centimetre, second) J, Joule's equivalent, equals 41,572,509, and the unit of heat is the quantity necessary to raise one gramme of water 1 degree centigrade.



Now, if e is the quantity of heat lost by radiation and convection per second per square centimetre of surface per unit difference of temperature between the hot body and the enclosure, and if v is the difference of temperature between any point F and the enclosure, the absolute loss of heat from a very small piece of the rod dl at the point F is, per second, $e\, 2\pi r\, dl\, v$.

If a and b be two sections of the rod separated by a distance dl, and K be the heat conductivity, then the quantity of heat conducted per second towards A across the section b equals $K \frac{dv}{dl} \pi r^2$, and the quantity of heat conducted per second towards A across the section a equals, by Taylor's theorem,

$$K \frac{dv}{dl} \pi r^2 - K \frac{d^2 v}{dl^2} \pi r^2 dl + \text{terms of a high order.}$$

Therefore, the difference must be the loss of heat by conduction from the piece of the bar included between the sections a and b, and this equals $-K \frac{d^2 v}{dl^2} \pi r^2 dl$; but, since we presume that the temperature of any one point of the bar is constant—that is, the temperature of the bar has settled down to a constant state—although the temperature of different points is very different,* the loss of heat by emission and conduction must equal the amount generated per second by the electric current, or

$$K \frac{d^2 v}{dl^2} \pi r^2 dl - e\, 2\pi r\, dl\, v + \frac{C^2 \rho\, dl}{J \pi r^2} = 0,$$

which, when simplified, becomes

$$K \frac{d^2 v}{dl^2} \pi r^2 - e\, 2\pi r\, v + \frac{C^2 \rho}{J \pi r^2} = 0,$$

* Expressed in the language of Prof. C. Maxwell, shortly, by saying the temperature of the bar is *constant*, but not *uniform*.

the general differential equation determining the temperature of any point of the bar. Dividing by $K \pi r^2$, and writing P for $\frac{e\,2}{K r}$ and Q for $\frac{C^2 \rho}{K J \pi^2 r^4}$, we have

$$\frac{d^2 v}{dl^2} - P v + Q = 0,$$

the solution of which, by integration, may easily be found to be,

$$v = A \epsilon^{l \sqrt{P}} + B \epsilon^{-l \sqrt{P}} + \frac{Q}{P},$$

where ϵ is 2·71828, the base of the exponential system of logarithms, and A and B arbitrary constants. To determine the values of these we have the two conditions, if L be the total length of the bar—viz.,

$$\text{when } l = 0, \quad v = 0,$$
$$\text{and when } l = L, \quad v = 0;$$

that is to say, that the wires leading the current into the comparatively thin incandescent rod A B are so thick that the temperature at the points A and B is practically that of the air, and the difference of temperature v is, therefore, nought.

Substituting the values for l and v given above, we have

$$0 = A + B + \frac{Q}{P},$$

$$0 = A \epsilon^{L \sqrt{P}} + B \epsilon^{-L \sqrt{P}} + \frac{Q}{P}.$$

Solving these equations, we find

$$A = \frac{Q}{P} \frac{\epsilon^{-L \sqrt{P}} - 1}{\epsilon^{L \sqrt{P}} - \epsilon^{-L \sqrt{P}}},$$

$$B = \frac{Q}{P} \frac{1 - \epsilon^{L \sqrt{P}}}{\epsilon^{L \sqrt{P}} - \epsilon^{-L \sqrt{P}}}.$$

$$\therefore v = \frac{Q}{P} \left\{ \frac{\left(\epsilon^{-L \sqrt{P}} - 1\right) \epsilon^{l \sqrt{P}} + \left(1 - \epsilon^{L \sqrt{P}}\right) \epsilon^{-l \sqrt{P}}}{\epsilon^{L \sqrt{P}} - \epsilon^{-L \sqrt{P}}} + 1 \right\}$$

Now the centre of our incandescent wire will be the hottest point, let the difference of temperature of this point, and of the enclosure be V, then we have the conditions

$$\text{when } l = \frac{L}{2}, \text{ then } v = V,$$

which gives us

$$V = \frac{Q}{P} \left\{ 2 \frac{\epsilon^{-\frac{L}{2} \sqrt{P}} - \epsilon^{\frac{L}{2} \sqrt{P}}}{\epsilon^{L \sqrt{P}} - \epsilon^{-L \sqrt{P}}} + 1 \right\} \quad . \quad . \quad (1)$$

as the final equation for determining the strength of the current required, and which connects the temperature of the middle point of the wire, its dimensions, specific resistance, heat conductivity, and surface emissivity with the electric current necessary to flow through it.

(TO BE CONTINUED.)

ELECTRIC LAMPS ACTING BY INCANDESCENCE.

A Paris correspondent writes to us as follows:—

"The first idea of a lamp by incandescence would appear to be due to an Englishman, Mr. King, who took out a patent in 1845. I am not aware whether you know anything of Mr. King, or whether his name has been connected with other inventions. However this may be, his patent contains several new and important ideas. He indicates the use of carbon; he proposes to enclose it hermetically; and, lastly, he points out that several of his lamps may be inserted in the same circuit.

"The division of the electric light was thus shown to be possible as far back as 1845.

"This invention was no doubt in advance of the times; it did not attract attention; and it certainly was forgotten when it was made a second time by M. Lodyguine, of St. Petersburg, in 1873 or 1874. Several Russian physicists have since worked in the same direction, and have made a great number of very interesting experiments. And even a few practical applications of the lamp with incandescent carbon have been made in Russia.

"At the commencement of the year that has just concluded, M. Regnier took up the same problem, and succeeded in making great progress towards a practical solution. He found a means of obtaining the gradual consumption of the incandescent carbon instead of the destruction, by breakage at the middle point, of the small pencils of carbon employed by his predecessors.

"M. Regnier realised the fact that a point of incandescent car-

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bon, resting upon a massive portion of the same material, must establish a somewhat imperfect contact, and consequently determine a point of maximum resistance and maximum heating effect. This effect, and also the consumption of the carbon, by combustion or otherwise, being thus localised, it was necessary only to cause the carbon C (Fig. 1) to move in the direction of the mass J in order to obtain a constant light.

"Such is the Regnier lamp in its theoretical simplicity; the incandescence of the carbon is confined to that portion which is included between the point and the collar, or contact *t* situated at a short distance from it. With this arrangement it is no longer necessary to place the carbon within a close vessel; there is no serious objection to its combustion by reason of the incandescence, and this combustion may even serve to raise still further the temperature of the pencil. Still, the use of a closed vessel would have the advantage of checking the consumption of carbon, and prolonging the duration of the light; and it is very possible that M. Regnier may some day revert to this device.

"The action of the lamp may be advantageously studied by projecting the image of the carbons upon a screen; we may thus clearly perceive the progressive motion of the moveable pencil, that it is more heated and narrowed towards the point, that there is no voltaic arc, &c.

Fig. 1.

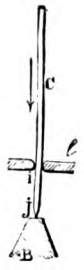


Fig. 3.

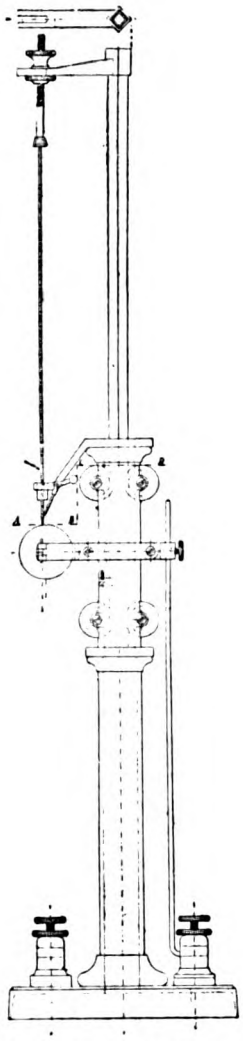
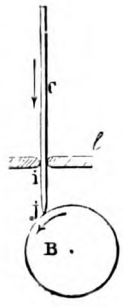


Fig. 2.



"From the period of his first experiments, M. Regnier noted the fact that the consumption of the carbon was not confined to the pencil of this material, but that the mass of carbon in which it rested became hollowed. He perceived that the most brilliant portion of the light became hidden within the cavity that was produced; and he avoided this difficulty by using as a support the disc of carbon D (Fig. 2), and causing this to revolve so as constantly to present a new point of contact for the incandescent pencil.

"As might be expected, he employed in the first place somewhat complicated means to produce this motion; and it was only by several successive steps that he arrived at the present apparatus, one of the latest forms of which is represented with tolerable accuracy by Fig. 3. The carbon-holder descends by its own weight between four rollers; it presses the pencil against the carbon disc in the line A B at a point which is somewhat in advance of the vertical falling upon the axis, so that the descent of the carbon itself causes the disc to advance. The disc itself acts as a break upon the carbon-holder, so that its weight is supported and its descent retarded.

"The apparatus works with great regularity, either alone or with other similar lamps in the same circuit, or again in circuit with a regulator lamp for the voltaic arc.

"With a current of from 6 to 8 Bunsen elements, the light evolved by a single lamp appears more powerful than that produced by two lamps placed in the same circuit.

"We have seen eight lamps in action together in a circuit of thirty Bunsen elements; this experiment was made on the 13th ult. before the *Société d'Encouragement*. One or two of these eight lamps were extinguished and relighted several times without interfering with the action of the others. This last point is one of capital importance; for, if any accident happens to one of the lamps, it short-circuits itself and the others continue to burn.

"Lastly, we were present on the 19th December at some experiments upon a rather large scale at which we were shown simultaneously:—

"1. A Gramme machine working eight Regnier lamps; these lamps were placed in offices, and furnished a very regular and agreeable light.

"2. A second series similar to the first, and worked by a second Gramme machine.

"3. A Gramme machine working simultaneously a Serrin lamp (with voltaic arc) and three Regnier lamps.

"4. A machine constructed for laboratory use, turned by hand, and working a single Regnier lamp."

THE PHONIC WHEEL OF M. PAUL LACOUR, OF COPENHAGEN.*

(Exposition Universelle of 1878.)

(continued from page 76.)

Although the mean velocity of the phonic wheel is perfectly uniform, the accelerating and retarding action produced upon each tooth at the moment of its passage in front of the electro-magnetic pole determines a variation in which the velocity is a *maximum* at the moment when the teeth arrive in front of the pole, and a *minimum* when the hollow spaces pass the pole. If the moment of inertia of the wheel is considerable, this variation of velocity will not be sensible; but if it be small the variation may readily be observed by blackening the exterior surface of the wheel and placing beneath it a sheet of white paper, as shown in Fig. 7. The wheel may then appear as a black disc, the edge of which is fringed with black and grey intervals, stationary, and equal in number to the teeth of the wheel. If, however, the wheel be large, this is not the case; a circular border of uniform grey is then perceived. With a small wheel the same may occur if the weight be sufficiently augmented, which sufficiently demonstrates the proposition stated. This experiment allows it to be shown also that the fewer the number of vibrations of the interrupter which furnishes the phono-electric currents, the more marked are the variations of velocity in the phonic wheel; and this circumstance explains why the movement of a phonic wheel revolving by the effect of very deep sounds is irregular.

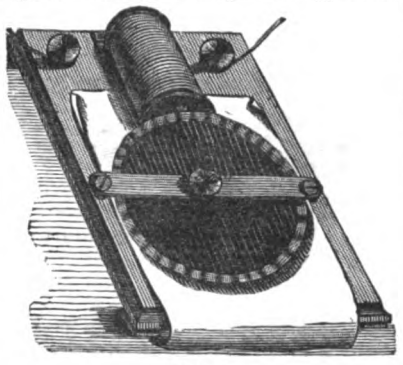


Fig. 7.

If those phonic wheels which possess considerable inertia escape from the variations just mentioned, they are on the other hand affected by reactions of another kind which may produce oscillations which are explained by M. P. Lacour, and which may be rendered sensible to the eye by placing one above the other two phonic wheels influenced by the same phono-electric current, and so arranged that the circular zones of a grey colour produced by the passage of the teeth intersect each other at a point of their circumference when they are viewed from above, as shown in Fig. 8. If the wheels revolve in the same direction, the teeth, at the point of their crossing, will move in opposite directions, and the grey circular zone formed by the spaces and the teeth of one of the wheels will partly coincide with the circular zone determined by the spaces and teeth of the other wheel; whence it will result that this common space will appear to the eye as a striated field. These *striæ* will appear stationary if the wheels revolve regularly, or even if their velocity changes

* Translated from *L'Electricité*.

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at the same period and to the same extent; but if the velocity of one of the wheels differs from that of the other, the *striæ* will seem to advance in the direction of that wheel which moves the quickest. And if we alternately augment and diminish the velocity of one of the wheels, whilst that of the other remains constant, the *striæ* will appear to oscillate; and it is precisely these oscillations, produced when the wheel undergoes oscilla-

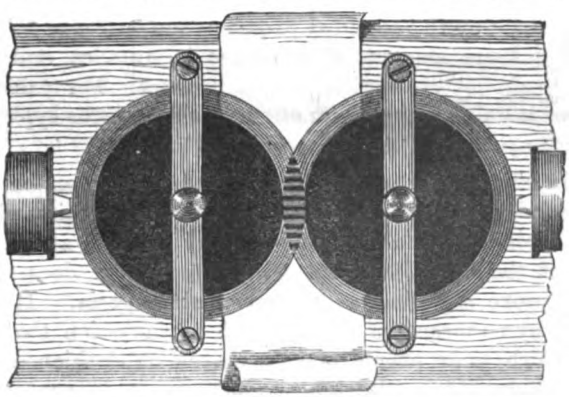

Fig. 8.

tions of velocity, which demonstrate the existence of the latter. When they are attentively studied, it is seen that their amplitude coincides with the periodical augmentations or diminutions which the ear detects in the sound, and that the *striæ* gradually diminish as the periodic variations in the sound diminish, and disappear when these variations cease.

If the phonic wheel at rest or in regulated motion receives a slight shock, it will, of course, commence to oscillate, and if a sound concussion affect it so as to augment the oscillation that the wheel is making, the amplitude of the latter will be increased. It will be understood, therefore, that after a certain number of such repeated shocks a period will arrive at which the oscillation will be sufficiently great to destroy the equilibrium of motion, and under these conditions it is impossible to depend upon the uniformity of motion of the phonic wheel.

To obtain from a phonic wheel a regulated movement free from the variations which we have just studied, it is necessary only to attach to its upper surface a cylindrical capsule filled with mercury, as shown in Fig. 9. This capsule, which should be of

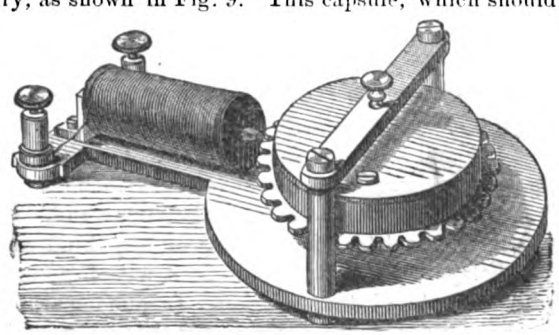

Fig. 9.

wood, is hollowed out so as to present an annular trough, over which is glued a wooden cover. The effect produced by this capsule is not that of a simple augmentation of the inertia of the system, but consists of a constant attenuation of the oscillations of velocity through the *vis viva* communicated to the mercury at each alternate oscillation, which becomes annulled by the oscillations which follow.

We may now study the principle of some of the most important of the numerous applications of which, as we have said, the phonic wheel is susceptible.

Application as a Chronograph.—Chronographs, as our readers are aware, are instruments intended to measure very small intervals of time occurring between two or more phases of a phenomenon to be studied. To obtain this measure, it is essential that the motor which supplies the indications should possess a perfectly uniform motion; and we have seen that this is precisely the problem of which the phonic wheel affords a solution in the simplest manner.

If the limit of error applicable to this system of measurement be calculated in accordance with the data precedingly set forth, it is found that it is less than 1-25,000th.

Application as a Clock.—The mode of action of the phonic wheel renders it in certain cases applicable in horology. In effect, since three systems of apparatus concur in the production of its motion; and since these systems may be placed any required distance apart, we may, for instance, place the vibrating apparatus under such conditions that the external causes which act upon chronometrical instruments of precision are eliminated, and in this case the counting apparatus acted upon by the phonic wheel may furnish rigorously accurate indications at any spot where they may be required.

Again, since several phonic wheels may be introduced in the same circuit, or be controlled one by the other, we may have several clocks moving quite synchronously.

Lastly, a second hand, or any other moving with still greater rapidity, may accomplish its motion without any jar, and in a perfectly regular manner throughout its revolution.

Application for determining the number of vibrations in a sound.—The phonic wheel may be advantageously substituted for the syren in the determination of the number of vibrations in a sound. To obtain this result, the axis of the phonic wheel is furnished with an endless screw, which works a counting apparatus, as shown in Fig. 10. To facilitate the observation,

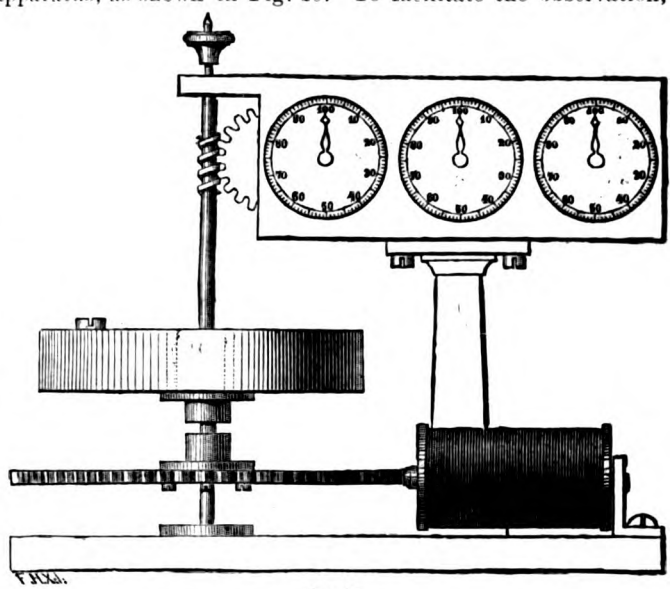

Fig. 10.

the counter may be arranged according to the decimal or centesimal system, so that the difference between two observations may give directly the number of waves that have traversed the electro-magnet of the phonic wheel during the time which has elapsed between these observations.

If the sonorous body can be maintained for a long time in vibration, it may itself be used as the apparatus for transmitting the current, and the counter, by indicating the number of times the circuit has been closed, indicates at the same time the number of the vibrations which have caused the circuit to be thus completed. But if the sonorous body be not adapted to react directly on the instruments, we may proceed as follows:—

Thanks to its moveable weights, the interrupting diapason may be brought into accord with any sound of which we wish to determine the value; but care should be taken to produce a slow beat, for example, one every two seconds, which is obtained by according the diapason higher or lower than the sonorous body.

"Let us take," says M. P. Lacour, "the first case; by means of the diapason we maintain in motion the phonic wheel provided with its counter. The beats must be counted with the greatest possible exactitude. The sound of the diapason will always be sufficiently strong to obviate the necessity of paying great attention to it, and the ear may be occupied with the sound which has to be determined, and which by this course may generally be heard during several seconds. Suppose it to be possible to hear it during ten seconds. Then, producing the sound several times over and counting each time the beats during ten seconds, one can find a mean number, say 5·3, the error in which may be within ·1 of a beat. In this way it has been found that a sonorous body has made 1·06 vibrations per second more than the diapason, a number which is true within ·02 of a vibration. As to the sound of the diapason itself, an observation of the counter and of the chronometer, before and after counting the beats, suffices in order to obtain the number of its vibrations with still greater exactitude.

"The facilities offered by the phonic wheel for very delicate measurements of the number of vibrations will probably contribute to throw a light upon the laws in connection with the effect upon the loudness of sound of temperature, atmospheric pressure, and other circumstances the effect of which cannot be measured with sufficient exactitude by means of the ordinary methods."

(TO BE CONTINUED.)

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NON-RECORDING TELEGRAPH INSTRUMENTS.

A short time ago we announced that the use of "sounder" instruments was being largely extended in this country, and that the experiment, so far, had been eminently successful. It will be worth while to review the circumstances under which this change appears to have been brought about; what are its bearings upon the question of non-recording instruments generally, and what openings, if any, are afforded to invention by the new departure.

The first electric telegraph naturally followed in the steps of its venerable predecessor the semaphore; and various forms of "needle" instruments giving non-recording visual signals were for a long time alone in favour. Competition started fresh ventures, and brought forth new appliances. The first striking novelty was the Bell instrument, which gave out audible signals upon two bells corresponding to the right and left beat of the "needle." Following upon this came the Bain, and then the Morse recording instrument, which latter for many years has virtually superseded its forerunners, but is in turn now threatened by a dwarfed image of itself deprived of everything that made its existence meritorious. We refer, of course, to the so-called Morse "sounder," which has attracted a large amount of patronage in America, and is aspiring to similar distinction in this country. For cables, the mirror is only another form of "needle," and the syphon is a delicate pattern of Morse recorder.

This, briefly, is how matters have moved. But, bearing in mind the exigencies of the various competing companies, who adopted diverse instruments for pecuniary reasons, and not because of their intrinsic superiority, the survey does not of itself prove anything as regards real progress. It is, therefore, by no means an indication of retrogression that a system which some people may regard as old-fashioned is reverted to now, if it can be shown to be best suited for present requirements. On the contrary, the more we look into the history of the Morse ink writer, for example, the more satisfied are we that it ought to be regarded as a mere episode, and not as a stage of improvement, in telegraphy. We can well understand how it fascinated the administrators of that day; its absolute novelty, the ease with which it could be read, its nimbleness as compared with the sluggish needle, and, above all, the permanency of its record—all combined to bring it straightway into high esteem. And, when once introduced, its very faults were such as to render its displacement a matter of extreme difficulty. Inexpert persons could read its signals with a minimum of practice, and what they could not read quickly they could take their time over. This last, indeed, is the fatal crime of the Morse printer, considered as an "all round" instrument; for its tendency, if not to actually encourage slow reading, has been the reverse of stimulating the operator to do his utmost. Great feats have been performed with "slip" reading; but it is notorious that the greater feat is always at the keying end of the wire; and that although there is *practically* little to choose between a fast Morse key and a pair of fast Bell keys, the advantage —taking the average work done under ordinary conditions— is usually favourable to the Bells at the receiving end. The fault is, in fact, inherent to slip reading of any kind whatever, where the speed of transcription does not of necessity coincide with the rate of transmission. In one department of telegraphy, however, the recording slip has been of immense service, for without it automatic fast-speed instruments would have been impossible. The record finds its useful province here, from which it is never likely to be ousted. It will also be required for exceptional purposes, such as those of actual warfare, where, perhaps, no other method could be relied upon, and record might be of vital consequence. But except for uses of this kind the advocates of slip reading seem at length to have yielded to the ever increasing urgency for expeditious signalling, as against simplicity and the evidence of record.

Seeing that by far the greater number of telegraphs have been and still are non-recorders, it would seem a waste of time to argue against the alleged advantages of a record. Some of these advantages have disappeared with the advance of skill attained by the operators; the rest are purely matters of discipline. Errors and miscarriages can be brought home to the offending clerk. A very able administrator, but one not possessing any large experience of telegraphy, once said in our hearing:—"I like my clerks to read by sound because they develop into the very best operators; but I make them let

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the slip run to 'spot' their mistakes." He has probably learnt by this time that the occurrence of serious errors, much more of wilful negligence, is so infrequent, that the game is hardly worth the powder. In the long run it will, we think, be found that handicapping in that way the very best operators and hardest workers, materially checks the wished for "development." The true aim of an administrator should be not to punish mistakes but to prevent them; and, as experience has shown that they are not more numerous on non-recorders than on recording instruments, the utility of spotting those committed on the last named systems becomes rather questionable. We say "not more numerous;" but as the ear is far more sensitive, and less liable to fatigue than the eye the work on "sounder" circuits is in all likelihoods better done than that performed by visual signals. At all events it is generally admitted that the clerks accustomed to acoustic instruments are superior as writers, as readers, and in general smartness, to the average run of operators.

Of all the non-recording instruments the Bell is ideally the most perfect. The sounds are emitted close to the ears of the receiver who sits between the bells, with undivided attention, and in a position fairly convenient for writing. If the speed at which messages can be received and written down by the clerk himself is a test of an instrument's merits, this instrument surpasses every hand-worked telegraph in existence. Unfortunately, its adjustments are ticklish, and it fails in bad weather over long land wires. With improved line insulation, however, the Bell instrument, or some modification of it, may have an honourable future before it. Its present successful rival is the Morse sounder—an ordinary electro-magnet with an adjustable armature. The simplicity of this instrument, its inexpensiveness, and its adaptability to the special aptitudes of clerks trained to the old Morse system, sufficiently explain its improving prospects. Its educating influence upon the operator is equal to that of the Bell; and it has the further electrical merit of working with or without relays, and with either single or double currents,—points which in a variable climate like ours more than counterbalance any inferiority to the Bell in respect to speed. As neither of these instruments requires "slip" the saving in the item of Morse paper is considerable.

All the circumstances, therefore, seem to point to acoustical non-recorders as the instruments of the future; and it is upon this class of appliance that improvement, if any is needed, should be attempted. The Bell system is easy to learn, and in some other respects is well fitted for the requirements of minor circuits; but its adjustments are precisely such as are beyond the capacity of the unskilful persons working such circuits. Simplification seems to be needed in that direction. As regards the Morse sounder, it is difficult to learn, the fact being that it was not made for sound reading. That it is so used is the result of pure accident, experienced clerks discovering that they could read by ear without the help of the paper. No man would ever have invented such a "sounder," for, theoretically, it is as imperfect as it well can be—a fact very instructive for theoretical inventors—its beat for dash and dot being undistinguishable, the difference having to be computed by the interval between the down stroke and its audible recoil. It is not surprising, therefore, that it takes a long time to make a good Morse sound reader if he has had no previous experience of Morse slip reading. Whether this is felt to be a practical inconvenience we are not in a position to say, but it occurs to us that if the sound could be prolonged while the current lasts a useful improvement would be effected. Elisha Gray's vibrating reeds, lately exhibited in this country, suggest a possible way of accomplishing it. With the recently discovered means of amplifying feeble sounds, and of applying telephonic principles to cable wires, the possibility of converting the "Mirror" into an acoustical instrument, and so saving the necessity for a writer, does not seem beyond the reach of ingenuity. But our space will not admit of our dwelling upon this part of the subject further at present.

CORRESPONDENCE.

GOVERNMENT MONOPOLY AND INVENTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to thank "Inquirer" for his letter on cable signalling in support of mine, and to express a hope that it may be followed by further correspondence upon so interesting and important a question. I must also ask permission to thank "Fair Play" for the additional evidence he has afforded of the reason why "England is behindhand in telegraphic invention." Of course, it would be ridiculous to expect a sincere desire for anything like "fair play" from a man who is ashamed to sign his name. He refers to a pamphlet of mine published by Messrs. Longmans and Co., entitled "Vis Inertiæ at the Post Office," and remarks, concerning it, "I make bold to say that the line Mr. Herring has pursued throughout has done more harm to outsiders generally than any amount of vis inertiæ in public departments could have inflicted. The example he has set is enough to frighten all reasonable men outside, and disgust every official inside departmental boundaries." This, I think quite likely. Indeed, it is the strongest recommendation the pamphlet has yet received, although it has been favourably reviewed by the Press, with scarcely a single exception. It is unnecessary for me to add one word to that pamphlet, and certainly I have no desire to take one word from it. The misrepresentations made under the absurd signature of "Fair Play" are one and all disposed of by that pamphlet. But, in order to prevent misapprehension either by the ghost of "Fair Play," or any of your readers, I will ask you to print "Counsel's Opinion" taken by my solicitors. No case was specially prepared upon which that opinion was given, but the whole of the papers and correspondence were submitted without preface or comment.—Yours, &c.,

27, St. Mary's-road, Canonbury. RICHARD HERRING.

OPINION.*

It appears to me that Mr. Herring is entitled to a fair and full performance of the agreement, which undoubtedly was entered into, to refer the question of the value of his invention to scientific persons chosen by the Post Office and by himself. I will first consider Mr. Herring's case on the supposition that he has been dealing with a Telegraph Company, and then deal with the fact that the Post Office is not a Company, but a branch of the Public Service.

There are several reported cases of actions for breach of agreements to refer, and it is clear that such an action may be maintained, although it may be likely to result in only nominal damages. Lord Eldon, in "Street *v.* Rigby," 6 Ves. 817, expressed an opinion that such action could not be maintained, but that opinion has been overruled. "Suppose," says he, "an action brought. The question would be, what the damages would have been, if the defendant had joined and named an arbitrator and evidence had been produced (and what that would be could by no means be correctly proved) and an award had been made, giving some supposed sum, which no proof could ascertain. The effect, therefore, of such a covenant is that as the damages are not to be ascertained by evidence, nominal damages only can be got."

That case arose on articles of partnership containing an agreement that all disputes relating to the partnership should be referred to arbitration. It was brought under the notice of the Court of Queen's Bench in "Livingston *v.* Ralle," 5 E. and B. 132, 24, L. J. Q., B. 269, which case decided that for the breach of an agreement to refer a matter of difference under a contract to arbitration, an action was maintainable. Mr. Justice Coleridge, in his judgment in that case says, "Lord Eldon seems to have doubted upon a difficulty as regards the assessing of damages, but the fact of the damages being merely nominal is no reason why the action should not be allowed, for the matter in question may notwithstanding be very substantial and important."

It appears to me that this passage has an important bearing on Mr. Herring's case. It was "very substantial and important" to him to have the agreement of reference *bonâ fide* performed, and if that agreement was made on sufficient consideration, I do not see why he should not have a right of action for breach of it.

In examining the facts I will take the statement of them from the pamphlet of August, 1874, and I will refer, if necessary, to the correspondence to complete the narrative.

At a conference held at the Post Office on 15th October, 1873, between Mr. Scudamore, Mr. Herring, and Mr. Law (Mr. Herring's solicitor) at which Mr. Patey, of the Post Office, was present, Mr. Scudamore says, "I consented on a former occasion that there should be another trial, and I am quite ready to act up to my promises made on that occasion." The

* The Case submitted to Counsel was the whole correspondence, without preface or comment.

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Promise made by Mr. Scudamore to Mr. Herring was substantially this: That if Mr. Herring would bring his instrument to the Post Office, in working order, Mr. Scudamore would try it. Mr. Herring bestowed time and thought in perfecting his instrument, and brought it to the Post Office, and Mr. Scudamore has refused to try it. Is not this a breach of agreement made upon consideration? Mr. Scudamore said at the same interview, "The next thing is for you to get an automatic transmitter. It would be a *sine quâ non* that I did not try it until you said, 'This is the thing I approve of.'" Mr. Herring did get an automatic transmitter accordingly. He instructed the maker of the transmitter, and Mr. Scudamore paid the maker's bill. I find here a consideration within the definition given in 2 "Williams' Saunders" ed. of 1871, vol. 2, p. 431, viz., "Any act of the plaintiff from which the defendant or a stranger derives a benefit or advantage, or any labour, detriment, or inconvenience sustained by the plaintiff, however small the benefit or inconvenience may be, if such act is performed or such inconvenience suffered by the plaintiff with the consent express or implied of the defendant, or, in the language of pleading, at the special instance and request of the defendant."

Mr. Herring supplied the design for the automatic transmitter, and superintended the making of it, and this he did at the express request of Mr. Scudamore.

Further, Mr. Herring brought to the Post Office his receiving instrument or "recorder," completed according to his latest ideas. I understand that the Post Office has repaid to Mr. Herring the money expended by him in constructing this instrument, but he has received no compensation for his skill and labour in designing it. He delivered this valuable instrument to the Post Office at the express request of an officer instructed by Mr. Scudamore, and the Post Office has kept it ever since, and claims to keep it altogether.

Again, Mr. Herring instructed Messrs. Clark, Forde, and Company to attend the trials on his behalf, and paid them a retaining fee, and this he did on at least the implied request of Mr. Scudamore. The basis of the interview was that there must be a "further trial" of Mr. Herring's instrument, at which persons appointed by Mr. Herring should attend. The interview was an invitation to Mr. Herring to appoint these persons, and he did appoint them, and he either has paid them or is liable to pay them for their attendance.

Thus I find three distinct acts of Mr. Herring, all of which seem to come within the definition of "consideration," and any one of which would, therefore, suffice to support the agreement of 15th October, 1873.

(1) Mr. Herring orders the automatic transmitter.

(2) He delivers the "recorder" complete.

(3) He instructs and employs and is liable to pay Messrs. Clark, Forde and Company.

If the consideration be sufficient, the next question is, what is the promise? I have said that Mr. Scudamore promised to try the instrument, by which I mean that it was to have a *bonâ fide* trial by persons independent of the Department. Mr. Scudamore promised this in the clearest terms, subject only to the limitation that he would only employ particular persons, and that he would not bring them to London on purpose for the trial. "I have no doubt," says he, "that they will be in London again, and I should have no objection to let them meet any gentleman Mr. Herring is disposed to appoint on his own behalf." Again, he says, "if Professor Thomson or Professor Jenkin is in London, Mr. Clark shall have the means of communicating with them." This I take to be an express promise on adequate consideration to refer the question of the practical value of Mr. Herring's invention to Messrs. Thomson and Jenkin jointly with Messrs. Clark, Forde and Company. I conceive that Mr. Herring is entitled to a *bonâ fide* performance of that promise. It is the duty of Mr. Scudamore to arrange a meeting at a convenient time between the arbitrators, as I will for shortness call them, on both sides; and it may be assumed that the arbitrators when they meet will do their duty. It may well be that a joint report of the arbitrators would be advantageous to Mr. Herring, and he would, at least, be entitled to enter into evidence to show that the report would be advantageous: I see nothing to prevent a jury giving him substantial damages, if they thought proper; and I can hardly doubt that he would produce on them the impression that he had been ill used.

It would be no answer to his case to say that, even on the most favourable report, he could not claim to have his instrument adopted. He certainly could not claim this, but a favourable report as the result of trial by the Post Office might be valuable.

The Post Office alone could furnish facility for such trial, they promised to furnish it, and they have evaded fulfilment of this promise. Mr. Scudamore's letter of 4th July, 1874, can only, I think, be described as an evasion. He says (p. 13 of pamphlet) "The experiments which the Post Office undertook to make have now ceased," which is true in a sense, but not in the sense which the context seems to require, viz.: that "the experiments which the Post Office undertook to make" have been completed. The Post Office undertook to make "full and fair trial," as Mr. Scudamore himself admits, and this it has not made. Messrs. Clark, Forde, and Company had seen, as they thought, enough of the working of the instrument, and they made their report on 5th June, 1874, and they have always since been ready to meet Messrs. Thomson and Jenkin, and Mr. Scudamore has been requested to arrange a meeting. The "experiments which the Post Office undertook to make" were such experiments as might be necessary for enabling the arbitrators to proceed properly and effectually at their meeting. But the Post Office has caused the experiments to cease without even inquiring whether the arbitrators desired them to go on.

It needs no authority to show that the Post Office must act *bonâ fide* in such a matter. I will, however, refer to "Leake on Contract," p. 335, where it is said that contracts to pay for work may be made subject to satisfaction on approval, and it may be stipulated that the satisfaction on approval shall be quite arbitrary, "and then the only restriction on the right of approval is that it must be exercised in good faith, and not merely for the purpose of defeating "the contract." He refers to the case of "Andrews *v.* Belfield," 2 C. B. N. S. 779, in which a carriage was to be built in such a manner as to meet the defendant's approval "on the score of convenience and taste." And it was held that the defendant was entitled (acting *bonâ fide* and not from mere caprice) to reject it. There is a letter among the correspondence (3rd September, 1873) in which Mr. Scudamore writes to Mr. Herring, "My remarks to you were to the effect that if I were satisfied that your instrument possessed the advantages which you ascribe to it, I should willingly recommend its adoption. At the same time I distinctly gave you to understand that the satisfaction must come to me from the scientific advisers of the department." Then a trial was arranged in order, if possible, to satisfy those advisers, and this trial, as I think, must be conducted "in good faith and not merely for the purpose of defeating the contract" or arrangement to try. It appears to me that there is evidence of a purpose entertained by Mr. Scudamore and Mr. Culley to conduct the trial so as to defeat the arrangement, and that the whole proceeding was illusory.

I have based my argument upon the arrangement of 15th October, 1873, as giving to Mr Herring a right of action for breach of its terms. But that arrangement can only be properly understood by reference to all that went before it, so that the whole story would need to be told to a jury, and I do not think that Mr. Herring would suffer by the recital.

It may perhaps be suggested that the arrangement of 15th October, 1873, proceeded merely from the grace and favour of the Post Office, and that the alleged consideration was not the real moving cause of the arrangement. But if, upon the facts, a consideration and a promise can be shown, any inquiry into the moving cause would be irrelevant. This appears from the case of "Thomas *v.* Thomas," 2 Q. B. 851, 11 L. I. N. S. 2 B. 104, where a paper was drawn up stating that, in consideration of the desire of a testator, his executors agreed to assign to his widow a house, and she agreed to pay to the executors 1*l.* a year towards ground rent. This paper was declared on as a promise to assign the house in consideration of a promise to pay the ground rent. That which was undoubtedly the real moving cause of the arrangement was disregarded in pleading, and when proved in the trial was held to be immaterial.

Supposing there has been a contract on sufficient consideration, and a breach of it, the plaintiff, in an ordinary action, would be "entitled to nominal damages," at all events, and such other damages of a pecuniary kind as he may have really sustained as a direct "consequence of the breach of contract," per Pollock, C.B., in "Hamlin *v.* Great Northern Railway Company," 1 H. and N. 408, 26 L. I., Ex. 20. The "direct consequence" of the breach of contract in this case appears to me to be that the fee paid by Mr. Herring to Messrs. Clark, Forde, and Company, the trouble which he took, and the skill and experience he bestowed in perfecting the receiving instrument or "recorder," which he delivered to the Post Office for the promised trial, and which, as I understand, has been retained by them up to the present moment, and also the trouble which he took in getting the automatic transmitter made, at the expense of the Post Office but to his design and satisfaction: all his trouble and expense incurred in the matter have been absolutely wasted. It is no answer to his claim, put in this way, to say that any estimate of his damage must be conjectural, because it is often the duty of juries to make conjectural estimates of damages. A striking instance of this will be found in the case of "Macrae *v.* Clarke," 1 L. R. C. P. 403, where, in an action against a sheriff for an escape, it was held that, in estimating the value of the custody, the jury may take into account not only the debtor's own resources, but all reasonable probabilities, founded on his position in life and surrounding circumstances, that the debt or some part would have been discharged if he had remained in custody. The amount of the judgment debt was 657*l.* The judge directed the jury to give as damages the value of the chance "that the debt or any part of it would have been extracted by the debtor's remaining in prison." The jury found a verdict for 197*l.* It is true that, in an action for breach of duty, which that was, the scope of damages is wider than in an action for breach of contract; but I only cite the case to show that a jury may be called upon to estimate "reasonable probabilities." And for that purpose I do not think the distinction between tort and contract is material. Suppose a man without means to be arrested for a debt of considerable amount, what is the probability that his friends will pay the debt or part of it rather than allow him to remain in prison? A jury answered that question and the court refused to disturb the verdict. It would not be more difficult to answer the question, what is the value of the probability that if Messrs. Clark, Forde, and Company had been placed in communication with Messrs. Thomson and Jenkin, the result would have been a report favourable to Mr. Herring's instrument?

An example of an estimate of probability in an action of contract will be found in "Lord Londes *v.* Fletcher," 5 B. and A., 835, where the action was on a bond to resign a living, and the jury gave as damages the value of an annuity equal to the income of the living for the life of the intended nominee of the plaintiff.

I have been unable to find any authority more exactly in point on the subject of damages, but I think I am right in assuming that the question of damages would be for the jury, and that if the jury gave substantial but moderate damages, the court would not disturb the verdict. Thus it has been decided that a banker's customer, if a trader, is entitled to temperate damages on his cheque being dishonoured without showing special damage. See "Robin *v.* Steward," 14 C. B. 595, 23 L. I. C. P. 148, where Mr. Justice Williams says, "The jury estimating the damages may take into their consideration the natural and necessary consequences which must result to the plaintiff from the defendant's breach of contract."

In that case counsel argued that no special damage having been proved, the defendants, though liable for their breach of contract, were only liable for nominal damages; but Chief Justice Jervis answered, "That would depend upon the circumstances." On the whole, I conclude that Mr. Herring would be entitled to submit all the circumstances to a jury, and that a jury would be very likely to give substantial damages. In cases of contract, the jury are not at liberty in general to look at motives, but if the whole circumstances are gone into, as I think they must be, the conduct of Mr. Scudamore and Mr. Culley must come before them, and would be likely, although unavowedly, to influence their verdict. It must be remembered that the Post Office have kept Mr. Herring's instrument, which embodies his invention in its most improved shape. They would, probably, urge that they have paid for the labour of making it, as in fact they have; but surely Mr. Herring is entitled to be paid something for the design. I see nothing in the case inconsistent with the notion of a joint property in this machine, and assuming that to be so, it would appear from the judgment of Lord-Chancellor Hatherley in "Jacobs *v.* Seward," 5 L. R. H. L, 464, that "where there has been a direct and positive exclusion of the tenant in common from the common property," an action of trover would lie. It does not appear, however, that any action *ex contractu* could be maintained, and

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there seems to be very few examples of suits in equity under such circumstances. See on this "Lindley on Partnership," 3rd edition, p. 69, "If part owners of an ordinary chattel cannot agree who ought to have it, the only remedy appears to be by a suit in equity for a receiver and a sale." I only notice this point in order that it may not seem to have been overlooked and not as intending to suggest that any separate claim should be made by Mr. Herring for the value of the instrument.

I have thus far proceeded, for the sake of simplicity, on the assumption that the Post Office would be liable like a telegraph company to an action at law. But, of course, Mr. Herring's only legal remedy, if he has any, against a Public Department, is by petition of right. It has been lately decided by the Court of Queen's Bench in "Thomas *v.* the Queen," 10 L. R. Q. B. 31, that a petition of right will lie for a breach of contract resulting in unliquidated damages. Unless that decision should be reversed on appeal, it is, I think, sufficient authority for Mr. Herring to proceed upon.

I may venture to remark that although I have written this opinion after that decision was given and reported, the substance of my opinion was communicated to Mr. Herring before the argument of that case, and I am somewhat encouraged in my general view of Mr. Herring's case by finding it in point of law supported by such authority. The petition of right in that case follows the very form that I had suggested to Mr. Herring. It resembles a declaration in an action on a special contract. It states that the suppliant had invented a system of artillery and desired that the same should be adopted into the public service, and the suppliant having had interviews and correspondence with the Secretary of State for War, it was mutually agreed by and between the suppliant and the Secretary for War, that in consideration of the suppliant's referring such invention to the Ordnance Select Committee at Woolwich, and of such committee receiving from the suppliant such descriptions and drawings or models as might be necessary for its elucidation to be retained for future reference and to enable the committee to give an opinion on the subject, and of the suppliant's attending the committee in order to give his personal explanation, that in the event of the invention being approved of and being adopted in the service, a reward in that behalf should be given by Government to the suppliant, and that the amount of the reward should be determined by the Master-General and Board of Ordnance. There was then an averment that all conditions precedent had been fulfilled, "yet the amount of the award had not been determined, nor had the same nor any part thereof been paid to the suppliant." A demurrer to this paragraph of the petition of right was put in by the Crown, and after argument and full consideration, overruled. Mr. Justice Archibald, who was formerly counsel to the Treasury, was one of the judges who gave the decision, and, unless it be reversed, it will furnish a precedent on which a petition of right might be framed in Mr. Herring's case. It would appear from that case that the suppliant would be entitled to ask a jury to estimate the value of the probability that a reward would have been given to him by Government for his invention.

I answer the questions put to me as follows:—

1. I think Mr. Herring would, under the circumstances, have a cause of action against a Company for breach of agreement to test the value of his invention.

2, 3. If this be so, the agreement having been made and broken by a Department of the Public Service, viz., the Post Office, Mr. Herring's remedy would be by petition of right against the Crown.

4. I think the whole case would be for a jury; my impression is that Mr. Herring would be likely to recover substantial damages. But this is only my own estimate of the view likely to be taken of the case by a jury, and no legal knowledge is required to form an opinion on this question.

I think a letter should be written by Mr. Herring's solicitors to the Postmaster-General, distinctly requesting him (as Mr. Herring has already done) to take steps for appointing a meeting between Professors Thomson and Jenkin and Messrs. Clark, Forde, and Company, at any convenient time when Professors Thomson and Jenkin may be in London, and intimating that if the department perseveres in refusing to do this, Mr. Herring will proceed as he may be advised to obtain damages for breach of contract.

J. M. HAYMAN, Temple.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Since posting my letter in reply to "Inquirer," I find he has noticed my mention of the use by me of special paper, and that he wishes to know if the marks of the electric current on paper saturated with iodide of potassium can be made less evanescent or even permanent.

Certainly. Several bright cream writing papers, such, for instance, as "Joynson's," which contain a large proportion of starch, if saturated with iodide of potassium, leave permanent blue marks where the electric current passes. "Inquirer" will excuse my mentioning what special paper I prefer until an appropriate opportunity is afforded me of submitting the means whereby the minimum time of discharge and the maximum speed of transmission of separate and distinct signals through submarine cable may be recorded. Of course, the paper must be free from chlorine if iodide of potassium and starch are used, and therefore it would be safer to select such and then to damp it with the iodide of potassium in combination with thin arrow-root.—Yours, &c., RICHARD HERRING.

27, St. Mary's-road, Canonbury, 6th Jan., 1879.

THE MICROPHONE AND TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In making some experiments recently with a Hughes' microphone, as represented in *The Electrician* of July 27th, I found that by using a Bell telephone, the coil of which consisted of No. 26 wire instead of the ordinary No. 40, the volume of sound was many times increased, this, of course, being owing to the less resistance of the thicker wire. This telephone gives but poor results when used in conjunction with an ordinary Bell telephone. But the very fact of its being less sensitive recommends it for use with a Hughes or Edison carbon transmitter over lines where the induced currents are very strong, as I find these latter have very little effect on the thick wired telephone, while much better results are obtained.

By varying the thickness of the vibrating diaphragm, the length and thickness of the wire, and the strength of the battery, I have no doubt most satisfactory results would be got.—Yours, &c., P. B.

Jan. 1, 1879.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following arrangements are sent with a hope of being some use to your readers.

In trying Professor Hughes's microphone, I substituted for the vibrating board a copper disc, 7½ inches in diameter, cut from a sheet that had been used in a Sir W. Thomson Tray cell. With the vibrating board I got no readable words, but with the disc every word was easily read. This was tried on about 400 yards of cable underground with seven Minotti cells.

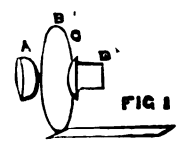

FIG 1

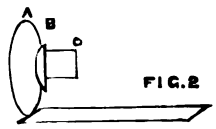

FIG.2

I also tried a disc of iron, about three times thicker than the above-mentioned disc, placing invertedly at the back the bell of an electric bell. On lightly striking the bell, a very fine metallic ring came out on the telephone, sufficiently loud for a call signal; and through 100,000 ohms I got a slight ring.

Microphone arrangement:—

Fig. 1.—*a*. Bell. *b*. Iron disc. *c*. Wood insulator. *d*. Carbon.

Fig. 2—*a*. Copper disc. *b*. Wood insulator. *c*. carbons.

From these arrangements I feel sure that had the bell, disc, and voice been of the same note, or quality of sound, I could have got a greater volume of sound on the telephone.—Yours, &c., G. J. BURRIDGE.

Cable Bay, Nelson, New Zealand, October 31st, 1878.

MEASUREMENT OF CURRENT IN ABSOLUTE UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am obliged to Mr. Fitzgerald, p. 82, for pointing out an error in the formulæ I gave for the action of the tangent galvanometer. My obligation would be even greater if I were myself responsible for the formulæ, but I took them from "Clark and Sabine's Electrical Formulæ," thinking they were recognised electric property. Not having had occasion to use them myself, and avoiding, in fact, as much as possible all such things, I did not notice the discrepancy.—Yours, &c., J. T. SPRAGUE.

PROFESSOR BARRETT AND MR. EDISON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your report of Professor Barrett's lecture on Edison at the London Institution, the lecturer is made to say that "the motograph telephone was of earlier date than the speaking telephone invented by Professor Graham Bell in 1876." The date assigned in a recent number of this journal, to the motograph telephone by Mr. Prescott, who ought to know, is the 23rd November, 1877. Will Professor Barrett be so good as to explain this discrepancy?—Yours, &c., J. C.

A SIMPLE ELECTRIC PEN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Wentworth Lascelles Scott deserves our hearty congratulations on having, to all appearances, "scored one" this time. His contrivance is indeed a *pen*, and an *electric* pen, in a sense which cannot be attributed to the Edison device of that name. It is to be hoped Mr. Scott will perfect the invention and exhibit it before the Society of Telegraph Engineers.—Yours, &c., M. S. T. E.

PROFESSOR W. E. AYRTON'S "NOTE ON THE ELECTRIC LIGHT."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would Mr. Ayrton or any of your correspondents kindly explain a little more fully in what respect the electrical conditions are *altered* when the carbons are inverted; so as to account for the arc shifting its positions from the extremity to the base? The phenomenon is exceedingly curious; but I, for one, cannot follow Mr. Ayrton's suggested explanation.—Yours, &c., JUDEX.

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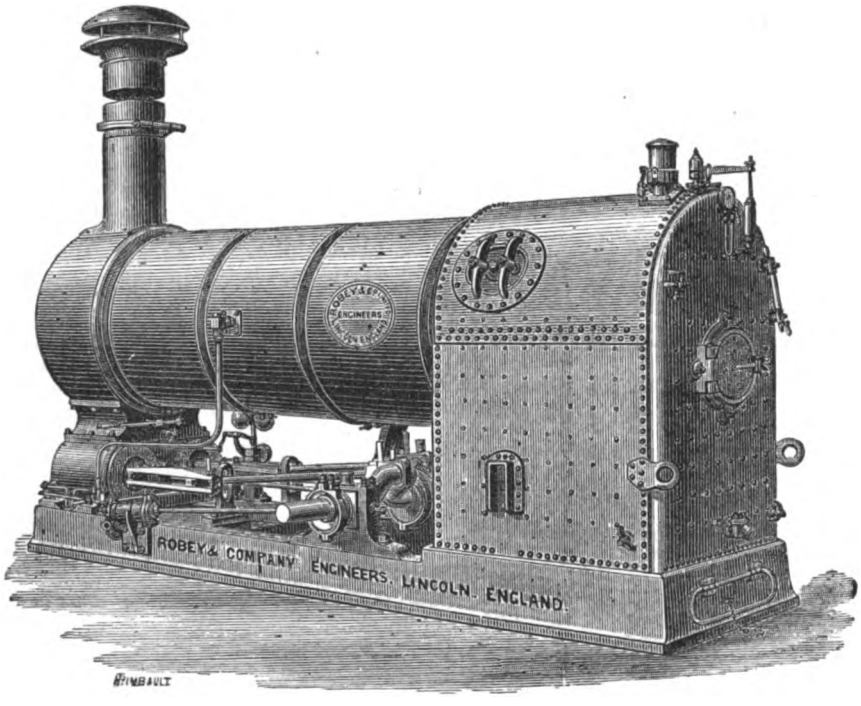
THE MOTIVE POWER TO DRIVE DYNAMO-ELECTRIC MACHINES.

We this week give an illustration of a semi-fixed engine, made and patented by Messrs. Robey and Co., of Lincoln. It will be remembered that one of Messrs. Robey's engines is used to drive the Gramme machines, which supply the electric current for the lights along the Holborn Viaduct. These semi-fixed engines are being used for various purposes to a considerable extent, and present many features of value. It will be seen from the illustration that space is economised to the greatest extent by adopting the locomotive type of boiler, and utilising the space between the boiler and the bed-plate. This bed-plate is a massive cast-iron plate, one end being formed into an ash-pit, with damper doors, and to this the fire-box end of the boiler is fixed. The other end of the boiler rests upon a crutch-shaped casting fixed over the cylinders of the engine. The end of the bed-plate under the cylinders forms a feed water tank, into which the cylinder cocks discharge all condenser water, and into which a portion of the exhaust is forced, thus heating the feed water to near boiling point. By the means we have thus briefly indicated, the whole forms one massive piece of workmanship, and requires little or no artificial foundation. The boiler, being free from all strain of the engine, is simply designed to accomplish the object in view, viz., the generation of steam. In thus glancing rapidly at these motors, we would again call the attention of our engineers to the vast field which electricity opens out to their inventive talent in economically combining the steam and the electric engine in one compact whole. As is well known, notwithstanding the great efforts that have been made, a vast amount of the heat of the fuel is uselessly expended. The steam engine is far from perfect, inasmuch as it does not use this heat. Is it impossible to electrically use some of the heat escaping at a temperature of 400° or 500° up the chimney? Take, once more, the old illustration of thermo-electricity, where heat applied to the junction of two metals generates a current. Could not our engineers design a smoke-box surrounded by thermopiles and maintain at one end the temperature above mentioned, whilst the temperature at the other end could easily be kept at that of the air or water? It is not improbable that by some such method a sufficiency of electricity would be generated by the waste heat to supply, say, one electric light, or to drive a small dynamo machine, to magnetise a large one, or in half-a-dozen other ways which engineers and electricians have no difficulty in understanding. The expenditure of a comparatively small sum in the hands of thoroughly competent men would soon set the question at rest whether the waste heat of an engine could be used electrically with economy or not. Will some of our large firms give a little attention to the question. To return, however, to our immediate subject. It cannot be too often pointed out that for the electric light, when the current is supplied from a dynamo-electric machine, it is essential that the revolutions per minute be constant. Any fluctuations act and react upon all parts of the machine, and cause variations in a greater ratio than the mere decrease in the number of revolutions indicated. Roughly, the action may be thus explained. Say the number of revolutions is 800 per minute, and that by some sudden increase in the resistance, the number is reduced by 20. We lose more than 1-40th of the light, although at first sight that seems to be the amount that should be lost, for, be it remembered, that in dynamo machines the magnetism of the coils varies with the revolutions, and therefore not only do we cut through the tubes of force a less number of times per minute, but we have a less number of tubes of force to cut through. It is essential, therefore, that the governor applied to an engine to be used for electric light purposes, should be capable of regulating the supply of steam with the greatest exactness under the most trying circumstances. We doubt if the old stock example of a combined steam-engine and water-wheel must not give place to the electric light as the most delicate test of the capabilities of a governor. Messrs Robey pay particular attention to this requirement, and we trust that an extended practice will show that the excellent governor they use is quite equal to anything it may be called upon to perform.



THE ELECTRIC LIGHT.*

By W. H. Preece, Memb.Inst.C.E., V.P.Soc.T.E., Electrician General Post Office, &c.

(concluded from page 84.)

6. Let us now assume the n resistances to be connected up in *multiple arc*; then the joint resistance will become $\frac{l}{n}$, and the heat generated will be

$$H'' = \frac{E^2 \frac{l}{n}}{\left(\rho + r + \frac{l}{n}\right)^2}; \quad \ldots\ldots (4)$$

and the maximum amount of heat will occur, as before, when

$$\rho + r = \frac{l}{n}.$$

7. Now, in the first case, if the internal resistance of the battery and of the connecting wires be very small compared with $n\,l$, we may neglect them; so that, by putting $\rho + r = 0$, equation (3) becomes $H' = \frac{E^2}{n\,l}$; or *the total amount of heat generated in the resistances will vary inversely as the number of the latter in circuit.*

8. In the second case, we neglect $\rho + r$; for here the greater we make n, the smaller $\frac{l}{n}$ becomes with respect to $\rho + r$; so that

* Communicated by the Author to the *Phil. Mag.*, Jan., 1879.

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if eventually $\frac{l}{n}$ becomes very small, we may neglect it in the denominator of the fraction. Then

$$H'' = \frac{E^2 \frac{l}{n}}{(\rho + r)^2} = \frac{E^2 l}{n(\rho + r)^2}; \quad . \quad . \quad . \quad . \quad (5)$$

so that in this case also *the total heat generated in the resistances will vary inversely as the number of the latter in circuit.*

9. Now it must be observed that in each of these cases the total heat is distributed over n resistances; and therefore, as compared with one resistance, the heat generated in each is only $\frac{1}{n^2}$ of that generated in one. So that, *joined up either in series or in multiple arc, the heat generated in each of a number of resistances varies inversely as the square of their number.*

10. With respect to the light emitted, if the amount of heat generated represented exactly the amount of light emitted, then the above equations would indicate the effects produced by multiplying the lights or subdividing the current when a constant battery is employed. But this is not so. The light obtained is not proportional to the heat generated. Below a certain limit the production of heat is not accompanied by light at all. In the case of incandescence, if the heat be distributed over two wires instead of one, inasmuch as the mass to be heated in the one case is double that in the other, the actual temperature to which each of the wires will be heated will be only one-quarter of that obtained with one wire, and the *total* light emitted will be half what it was before. In the case of the arc a similar result probably takes place; the incandescence matter, which is heated by the current, and which gives out the light, is increased by the addition of each lamp, and therefore diminishes the actual temperature of each arc, and consequently diminishes the light given out in direct proportion to the number of lights.

11. Moreover, in the arc the actual disintegration of the carbons and the transference of matter across the air-space, represent an amount of work done which must be deducted from that converted into heat, and which again tends to diminish the amount of light emitted. If, therefore, the lamps be joined up in series or in multiple arc, the light emitted by each lamp will vary inversely in a greater ratio *than* the square of the number in circuit.

12. We have assumed E to be constant; but if the current be produced by a magneto- or dynamo-machine worked by a steam-engine consuming a given amount of coal per unit time, E is no longer constant, for it varies with the resistances in the circuit. The constant in this case is the work done in the steam-engine in unit time. Calling this W_1, the total heat generated in the circuit when the lamps are joined up in series will be

$$H_1 = W_1 \times \frac{nl}{\rho + r + nl}; \quad . \quad . \quad . \quad . \quad . \quad (6)$$

and since the light varies inversely as n (§ 10), the light emitted

$$L_1 = W_1 \times \frac{nl}{n(\rho + r + nl)}; \quad . \quad . \quad . \quad . \quad (7)$$

and when joined up in multiple arc,

$$L_2 = W_1 \times \frac{\frac{l}{n}}{n\left(\rho + r + \frac{l}{n}\right)}; \quad . \quad . \quad . \quad . \quad (8)$$

Or, by putting $\rho + r = 0$ in equation (7), and $\frac{l}{n} = 0$ in the denominator of equation (8), we get $L_1 = \frac{W_1}{n}$ and $L_2 = \frac{W_1 l}{(\rho + r) n^2}$. So that *beyond* certain limits, when the current is produced by a dynamo-machine, if n lamps be joined up in series, the total light becomes diminished by $\frac{1}{n}$, and the light emitted by each lamp becomes diminished by $\frac{1}{n^2}$.

If they are joined up in multiple arc, the total light is diminished by $\frac{1}{n^2}$, and the light emitted by each lamp $\frac{1}{n^3}$. In the latter case the rapid diminution in the light emitted is due to the fact that the heat is developed in the machine itself instead of in the resistances external to it.

13. We have assumed W_1 to be constant; but this is only the case when a certain limit is reached, and when the velocity of the rotating coils in the dynamo-machine has attained a maximum. This limit will vary with each dynamo-machine and each kind of lamp used. With the Wallace-Farmer machine the limit appears to be reached when six lamps are connected up in series. With the Gramme alternating machine and Jablochkoff candles the limit appears to be five lamps. Beyond these limits the above laws will be true. It is this partial success in multiplying the light that has led so many sanguine experimenters to anticipate the ultimate possibility of the extensive subdivision—a possibility which this demonstration shows to be hopeless, and which experiment has proved to be fallacious*.

LIVERPOOL AND THE ELECTRIC LIGHT.

The borough engineer of Liverpool has recently submitted a report to the council of that borough which is worth more than a passing attention, inasmuch as the statements seem to be made after a considerable amount of care has been bestowed upon the thorough investigation of the subject. After some preliminary remarks upon the production of the electric light he refers to the lamps, and says:—

"With a few recent notable exceptions the lamps in which the energy of the electric current is converted into light are of the class known as regulators. Such lamps consist essentially of two pencils of carbon arranged in the same vertical line with their ends separated by a small space. The upper carbon is connected by a conducting wire with the positive pole, and the lower with the negative pole of the machine. The current having been once established meets, in passing from the upper to the lower carbon, with a certain amount of resistance by reason of the division between the two carbons, and at this point of increased resistance the energy of the electricity is converted into heat and light. The luminous ovoid space between the carbon points is known as the voltaic arc, and although owing to the small size of this space, very little heat is radiated, or carried upwards by the air, the temperature of the voltaic arc is so high that the most refractory substances may be rapidly consumed by it. Into this little furnace are projected by the electric current minute particles of the upper carbon and of the foreign matter associated with it, and from the crater thus formed in the upper carbon and the surfaces of the incandescent atoms, is emitted a light the intensity of which is little inferior, area for area, to that of the sun. With the carbons separated, as in their normal working condition, the voltaic arc cannot at first be established, and in order to establish it they must be caused momentarily to touch, or nearly to touch, each other. Moreover, there is a certain distance apart of the carbons at which the best light is produced, and as the carbons are constantly shortening by combustion—the upper one about twice as fast as the lower one—they must be constantly moving towards each other. Before ignition, therefore, the carbons must be touching, and when burning they must be separated by a certain space, and must consequently move towards each other at precisely the same rate at which they burn away. A mode of regulating the distance apart has been found in the fact that any increase of distance increases the resistance, and therefore diminishes the current, and by causing the strength of the current to determine the distance apart of the carbons, through the agency of an electro-magnetic apparatus contained below the lamp and actuated by the current, many inventors have produced electric lamps or regulators which have fulfilled, in a more or less perfect manner, the required condition. Regulators supplied with electricity by dynamo-electric machines, driven by steam or other motive power, have been extensively used within the last ten years for lighthouses, for naval and military signalling, for tidal and other engineering works, and in certain industrial establishments, and upon the efficiency of such combinations most of the statements laid before the public up to a recent date, as to the relative cost of electric lighting and gas lighting have been based. Perfectly true though those statements have been the inferences to which they have led have been most misleading.

"It is true, for example, that the cost of light from ordinary regulators having nominal illuminating powers of from 6,000 to 15,000 candles is, according to circumstances, only from one-fifth to one-half the cost of gas producing the same candle power; but in the case of the electric light a greatly-increased candle power is indispensible to produce the same degree of illumination, as the following considerations will show.

"The light from each regulator cannot be efficiently reduced below 1,000 candles, and gives a much higher efficiency when increased to 10,000 or 15,000 candles. Regulators giving 6,000 candles each are very commonly used. The most favourable place for the employment of such a regulator would be the centre of a circular space. If such a space were 500 feet in diameter, the light in the centre line of a circular carriage-way just within it would be greater than that in a Liverpool street illuminated in the ordinary way. To

* *Vide* Fontaine's 'Electric Lighting,' chapter xi.

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illuminate the whole area with gas rather better than the electric light would illuminate the centre of the supposed carriage-way, would necessitate the use of only about 125 Liverpool street lamps of sixteen candle power each. Thus with gas lights having an aggregate power of only 2,000 candles, a better effect is produced than with the electric light having a power of 6,000 candles, even in a case particularly well adapted to give the best result attainable from a concentrated light. It is obvious, therefore, that any comparison of cost based merely upon the relative candle power of electric and gas lights must be misleading, and yet upon this principle many of the published comparative statements have been based."

The subdivision of the light next claims attention, and the report gives a pretty full account of the Changy system, thus :—

"It appears, nevertheless, that as long ago as 1858 M. Jobert, of Brussels, a scientific man, according to M. Hippolyte Fontaine not likely to be carried away by the enthusiasm of an inventor, communicated to the Academy of Sciences, on the 27th February in that year, the following account of the complete success which M. de Changy had met with in dividing the electric light by the substitution of platinum in the regulator for the carbons generally employed. The opening words of M. Jobert, almost literally translated, were as follows : and in reading them one is readily reminded of a somewhat similar and equally enthusiastic communication with respect to an American invention for subdividing the electric light by the use of the same metal, which appeared in the English papers a few months ago :—

'I hasten to announce to the Academy the important discovery of the division of the electric current for lighting purposes, proceeding from one source by as many wires as may be desired, and producing any light, from that of a night light to that of a light-house.

'It is well known that the voltaic arc produces between two carbons a very intense flickering, disagreeable, and costly light. M. de Changy, at once a chemist, natural philosopher, mechanician, and practical man, fully conversant with the latest discoveries and apparatus, has just solved the problem of dividing the electric light. I have come from his laboratory, where he has worked alone for six years, to give a short account of what I have seen there.

'A battery of twelve Bunsen elements improved by him produced a constant luminous arc, without flickering or crepitation between two carbons governed by the most perfect and simple regulator I have seen ; further, there were twelve little miners' lamps—moveable on tripods—any of which might be lighted or extinguished without diminishing or increasing the remaining light. These lamps, enclosed in glass tubes hermetically sealed, are intended for lighting mines liable to fire damp, as well as for street lamps, which might all be lighted and extinguished throughout a town by simply opening or closing the circuit. The light is as white and pure as Gillard's gas, with which it has this one point in common—that it is produced by the incandescence of platinum. The gas pipes will be replaced by simple wires, and no explosions, fires, or smells can be caused. All previous attempts to produce electric light by the incandescence of platinum have proved abortive, owing to the melting of the wires from the want of a dividing current regulator, and this is the problem which M. de Changy has solved. He estimates the cost of the light at half that of gas.'

"In this manner M. Jobert continues to describe the lamp and the numerous uses to which it could be put. There is no reason to doubt the accuracy of his account of what he saw, but there is every reason to doubt the conclusions he drew, and the accuracy of M. de Changy's estimate of the cost. Very little more appears, however, to have been heard of M. de Changy's invention."

(TO BE CONTINUED.)

RECENT PATENTS.

1223. ELECTRIC TELEGRAPHS, *H. Wilde.—Dated 28th March*, 1878. 6*d*.

This consists in generating simultaneously electric currents or waves in a number of secondary circuits, so that each generating circuit being distinct from the rest, the strength of the secondary current can be adjusted to the resistance of the particular line of telegraph through which it is required to transmit signals without interfering with the working of the other circuits. In this improvement the alternating waves from a powerful magneto-electric machine are transmitted through the coils of a number of small electro-magnets, which experience reversals of their magnetism simultaneously with the reversals of the magnetism of the armature of the machine. The primary alternating currents are produced by means of a Pacinotti armature surrounded by a circle of electro-magnets placed at equal angular distance from each other, and with alternate north and south poles.

1442. PRODUCING LIGHT FOR PHOTOGRAPHIC PURPOSES, *G. E. Alder and J. A. Clarke.—Dated 11th April*, 1878. 4*d*.

Electric or other powerful lights are used in combination with reflectors capable of being fixed at any angle, but arranged to receive and reflect the concentrated rays in any desired direction. A semi-transparent medium, such as a screen of opal or ground glass, is interposed between the light and the object to be lighted, so that the reflected rays shall be dispersed or diffused equally.

1467. ORIGINATING AND DEVELOPING ELECTRIC CURRENTS, *H. C. Spalding.- Dated 12th April*, 1878.—*(Not proceeded with.)* 2*d*.

A series of dynamo-electric machines are brought into simultaneous action, so that a current of electricity produced in one shall be conducted through and intensified by passing through the whole series.

1522. GALVANIC BATTERIES, *P. Grabinger.—Dated 16th April*, 1878.—*(Not proceeded with.)* 2*d*.

A band of carbon corresponding to the size of the vessel, and a like band of amalgamated zinc are introduced into the vessel and maintained at their upper part at a suitable distance from and parallel to each other in the closing cork, so that the bands do not touch the bottom when the vessel is closed by the cork. The connection of the carbon with the conducting wire is effected by means of a small plate of platina, and the parts of connection have washers of hardened rubber.

1564. APPARATUS FOR IGNITING AND EXTINGUISHING GAS BY ELECTRICITY, &c., *W. R. Lake.—Dated 18th April*, 1878.—*(A communication.)—Not proceeded with.)* 4*d*.

The cock is opened or closed by means of a clock movement arranged to make and break the contact at proper times. The gas is ignited by making and breaking the electrical circuit, and thus producing a spark when the cock of the burner is opened. The conducting wires are supported by attachments, which may be readily affixed to any ordinary lamp post.

1889. LIGHTING GAS JETS BY ELECTRICITY, *A. R. Molison.—Dated 10th May*, 1878.—*(Not proceeded with.)* 2*d*.

A current of electricity is made to pass through a piece of platinum foil which it heats, so that when the gas impinges thereon it is ignited.

1927. ELECTRIC APPARATUS, *P. Jensen.—Dated 14th May*, 1878.—*(A Communication.)* 6*d*.

A bar or bundle of small central bars are employed, which carry a certain number of coils of conducting wire on the whole of its length, with the exception of a small space towards the top, and another space also at the base. Placed longitudinally close to each other is a first series of small sticks or rods, which touch each other and also the first coil ; the conducting wire is wound on this first series of sticks or rods, and so on to an undetermined number of series of sticks or rods, as well as of rows of intermediate conducting wires placed spirally around each series of sticks or rods, commencing with the central sticks or rods, or to an undetermined number ; this conducting wire remains always without being jointed to the exterior of the bobbin ; this is done by means of a passage between two rods of each series.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES Jan. 8.		BUSINESS DONE WEEK ENDING Jan. 8. Highest.	Lowest.
Anglo-American	57½,	58	58¼	57½
Do. "B"	83½,	¾	84½	83⅝
Do. "A"	32½,	33	31	32½
Brazilian	6⅞,	⅛	6⅝	6 7-16
Cuba	8¼,	⅜	—	—
Do. Ten per Cent. Preference	15½,	¾	15½	15½
Direct Spanish	1⅞,	2⅛	1⅞	1⅞
Do. Ten per Cent. Preference	9¼,	10½	9⅞	9⅞
Direct United States	11,	¼	11⅛	10¼
Eastern	7⅝,	⅝	7 9-16	7⅝
Do. Six per Cent. Debenture	103,	106	104	—
Do. Five per Cent. do.	101,	104	—	—
Do. Six per Cent. Preference	11,	¼	11¼	11
Eastern Extension	7⅛,	¼	7⅛	7 1-16
Do. Six per Cent. Debenture	104,	106	—	—
German Union	8,	¼	—	—
Globe Telegraph and Trust	4 15-16,	5 1-16	5 1-16	5
Do. Six per Cent. Preference	10½,	⅜	10½	10½
Great Northern	7⅛,	¼	7⅛	7 11-16
Indo-European	19,	20	—	—
Mediterranean Extension	2½,	3	—	—
Do. Eight per Cent. Preference	8¼,	9¼	—	—
Reuter's	9¼,	10¼	10	9¼
Submarine	215,	220	220	216¼
West India and Panama	1⅞,	2⅛	2	1⅞
Do. Six per Cent. Preference	8,	¼	8⅛	7⅞
Western and Brazilian	2½,	¾	2⅛	2 7-16
West. Union Seven per Cent. 1st Mort.	114,	118	—	—
Do. Six per Cent. Sterling	101,	103	101¼	101¼

TRAFFIC RECEIPTS FOR DECEMBER, 1878.

COMPANIES.	Dec. 1878.	Dec. 1877.	Increse.	Decrse.
Anglo-American Telegraph Company	47,040	45,570	1,470	—
Brazilian Submarine Company	14,231	12,318	1,913	—
Cuba Submarine Company	2,800	2,666	134	—
Direct Spanish Telegraph Company	939	857	82	—
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	22,929	23,980	—	1,051
Eastern Telegraph Company	38,467	37,777	690	—
Great Northern Telegraph Company	—	—	—	—
Submarine Telegraph Company	8,498	8,754	—	256
Western and Brazilian Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	5,304 estd.	4,558	746	—

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NOTES.

THE ELECTRIC LIGHT WITHIN DOORS.—It is proposed to light up by means of electricity some of the larger rooms of the Reform Club.

THE ELECTRIC LIGHT.—The directors of the Langham Hotel have adopted the use of the electric light with Serrin burner, tentatively, in the grand hall of the hotel.

DEATH OF MRS. FARADAY.—The death is announced, at the age of 79, of Mrs. Sarah Faraday, widow of the celebrated Professor Michael Faraday, who died August 25, 1865.

THE HISTORY OF THE ELECTRIC TELEGRAPH.—Messrs. Derby Brothers, of New York, announce the publication of a work by Mr. James D. Reid, entitled "The Telegraph in America."

ELECTRIC SPARK PEN.—An electric spark pen for producing engravings on copper or zinc has been invented by M. Bailey, of Paris. The light of the spark also guides the artist in a dark room.

THE GERMAN UNION TELEGRAPH AND TRUST COMPANY (LIMITED).—This Company have resolved to declare an interim dividend of 5*s.* 9*d.* per share, free of income-tax, payable on and after the 21st inst.

TELEPHONIC CIRCUITS IN GERMANY.—Since Nov. 5, 1877, the German telegraphic system has employed telephonic circuits. The number in use is 272. Practical use shows that communication can be satisfactorily carried on over a distance of from 30 to 40 miles.

THE TELEPHONE IN MINES.—We learn from the *Engineering and Mining Journal* that the Comstock mines have generally adopted the telephone as a means of communication from one mine to another, between the various levels, and between the different mines and their offices. Some of the California mines have telephone lines of from 20 to 30 miles in length.

TIME BALLS.—These useful indicators have been introduced into the German ports of Cuxhaven, Neufahrwater, Bremerhaven, and Swinemunde, so that chronometers can be regulated at these places. The time indicated is Berlin time, and, as is the case in England and America, the ball is connected electrically with an astronomical clock in an observatory.

LIVERPOOL AND THE ELECTRIC LIGHT.—A special meeting of the Liverpool Town Council was held on Jan. 15 to consider the propriety of promoting a Bill in Parliament to make provision for the lighting of the borough by the electric light, if thought necessary, and to provide for the purchase by the Corporation of the present gas company if it should be found expedient.—A resolution in favour of the proposed Bill was adopted by the Council.

ELECTRIC SPARK PHENOMENON.—M. De Wall has observed that when two electric sparks are simultaneously produced at the extremities of a short tube smoked inside, the two discharges give figures in the form of a black ring in the middle of the tube. When the sparks are not quite simultaneous the ring is slightly displaced. It is suggested by the author that this observation may afford a method of determining the velocity of sound, and of the speed of propagation of electricity in a conductor.

CENTRAL AMERICAN TELEGRAPHS.—The telegraph lines of Nicaragua and Honduras have lately been joined together by the completion of the missing link in Nicaraguan territory between Chichigalpa and the boundary between the two countries at Rio Negro. Telegraphic communication is thus complete throughout the four Republics of Costa Rica, Nicaragua, Guatemala, and Honduras, from San Juan del Sur to Mexico. A moderate tariff is to be enforced for through messages. In Honduras further extensions of the telegraph system are being made, and 150 miles of new wire are in course of completion, in addition to the 500 already opened.

ELECTROLYSIS OF WATER.—As a consequence of a long series of experiments, about fifty in number, each extending over several hours, and during which pressures amounting to 100, 200, and 300 atmospheres were employed, M. Bouvet invariably recognised the existence of the two following laws:—First, the decomposition of water by a current is independent of pressure; and, second, the quantity of electricity necessary to decompose a given weight of water is sensibly the same, whatever may be the pressure under which the decomposition is effected. The author has moreover observed that the oxygen and hydrogen gases are disengaged with equal facility, whatever may be the pressure. These two gases may be collected in a single receiver or in two; and in no case are there any secondary phenomena determining a recombination, even in part. The handling of the receiver containing the detonating mixture at a very high pressure is unaccompanied by any danger.

WHO FIRST SAW THE ELECTRIC SPARK FROM A LIGHTNING ROD?—Dr. Franklin promulgated his theory in 1749, and suggested experiments. Many philosophers hastened to prepare the apparatus indicated. According to Sturgeon, France claims the honour of having made the first observation. M. Dalibard erected his apparatus at Marley-la-ville. It consisted of an iron rod forty feet long, the lower end of which was brought into the sentry box, where the rain could not come. On the outside the rod was fastened by silken cords to three stout wooden posts firmly fixed in the ground. On Wednesday, the 10th of May, 1752, between two and three o'clock in the afternoon, Coiffer saw the first electric spark, drawn from the atmosphere, that was ever witnessed by man. He heard a clap of thunder at some distance, and on applying a small Leyden bottle to the iron rod electric sparks were obtained, and the great question set at rest about one month earlier than the period when Franklin himself had an opportunity of making a satisfactory experiment. This he did, by means of an elevated kite, in June of the same year, and without having any information of what had been done in France.

ELECTRIC LAMPS AND ORIGINAL INVENTORS.—So great has been the anxiety of men to do something in the way of inventing a new lamp, that in more than one instance old and well-tried designs have been re-patented. We do not impute any sharp practice to those who have taken out patents, but we have no hesitation in saying that the patents should not have been taken out. For the moment, light by

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incandescence is a popular direction for experiment. Werdermann shows a light, Reynier straightway claims that Werdermann has derived the idea from him, Werdermann replies by showing that Harrison patented a lamp on the same principle years ago; Edison claims to work in this direction, but is met with the rebuff that Starr (in England King for Starr) had done the work before; and now Professor Ayrton tells us that De Moleyns claims priority over all these men. The Wallace lamp is described in the *Mechanic's Magazine* of May, 1849, so that one begins to doubt if the money paid into the coffers of the Patent Office indicates any real progress. There is another reason, too, which makes us doubly doubtful of what has been done—real inventions are generally well tried before they are hurried into public gaze; and we question if many of the gentlemen who have favoured us with inventions really understand what is required.

A Hint for Students.—We fear too many students are satisfied with merely a superficial knowledge of their subject. We would advise as exercises that the experiments of the great pioneers of electrical science should be carefully considered, and that the student should give his explanation of the phenomena in the light of to-day. Thus De la Rive says:—"I have found that the magnetic electric currents are better conveyed by a heterogeneous conductor, than by a homogeneous one. I here give the experiment to which I refer for support in this opinion:—In traversing a conductor of the same total length, that is to say, a metre, but formed of two wires attached end to end, the one of iron, the other of copper, the current gave 75° (by the thermometer of Breguet); by putting in succession to each other four ends, alternately *copper* and *iron*, but always maintaining the same total length, this current indicated 76°; it gave 77° when the conductor was composed of eight ends alternately *copper* and *iron*. In each case the total length of the conductor was the same, and the copper and iron wires were always of the same diameter—a millimeter." I immediately add, "It is probably to the circumstance that the magnetic electric currents are composed of currents discontinued and alternately contrary, that their preference for heterogeneous conductors is due; whilst that voltaic currents and thermo-electric currents continued, are always travelling in the same direction, traverse with much greater facility homogeneous conductors."

Electrical Applications in China.—The pupils of the Imperial Torpedo School recently had a grand field-day at Hsika, near Tien-tsin, under the inspection of His Excellency Hung-Chang. For several days previously they had been engaged in connecting up a number of torpedoes sunk in the bed of the river. On a signal being given by the sound of a trumpet, five torpedoes, representing the external line of defence, were exploded, throwing up three or four immense columns of water. The second exercise consisted in the simultaneous explosion of a group of seven torpedoes, producing an effect comparable to that of an earthquake; and the third, similar to the first, produced seven columns of water, corresponding to the same number of torpedoes exploded. The fourth exercise consisted in establishing a number of subaqueous contacts, a work that was accomplished with great dexterity. In the fifth and last exercise, five torpedo-boats surrounded a flag representing the imaginary enemy they were sent to destroy. Each of these boats was armed with two torpedoes charged with about 50lb. of powder, which were to be exploded at a given signal. The experiment was a complete success. At first it was thought by some of the spectators that the boats had fallen victims to their temerity, for they had completely disappeared amongst the boiling waters; but soon they were seen to have collected together near the spot where the flag had been. This had disappeared—as would have done the most powerful ironclad under similar conditions. The director of the Torpedo School was warmly congratulated by the authorities; but, in regard to the pupils, as each one of them had constructed a torpedo, and as not one of the torpedoes had missed fire, the commendation was necessarily of a general character. These native pupils are now to take up telegraphic work, and have been ordered to commence the construction of the Tsien-tsin-Taku line. When this has been accomplished, they will be called upon to prepare plans for the construction of the Tien-tsin-Peking line, passing by Paouting-Foo.

Action of Water and Salt Solutions on Zinc.—The results of a series of experiments made upon this subject by Snyders may be given briefly as follows:—1. Zinc decomposes salt solutions, concentrated as well as dilute, without access of air or oxygen. Hydrogen is liberated, and oxide of zinc is formed. 2. The solubility of oxide of zinc in the salt solutions hastens and aids the reaction. 3. Oxide of zinc dissolves in solutions containing but 1 per cent. of salt, or even if more dilute. The solubility in different salts is different, being greatest in ammonia salts. It seems to be due to the formation of free alkali, inasmuch as it can exist in solution with a double zinc salt at certain temperatures and by certain concentration. Zinc carbonate and hydrate are not soluble in the carbonates. The solubility of zinc oxide increases as the temperature and concentration increase. 4. If the salt solution is saturated with oxide of zinc, the decomposition does not go any further, but the zinc oxide formed subsequently remains undissolved. But few experiments have been made in this direction, and others will be instituted by the same person. 5. With access of oxygen free from carbonic acid the oxide dissolves more rapidly because the zinc oxidizes at the same time. The salt aids this oxidation, not directly, but by keeping the surface clean. This, too, requires to be substantiated by further experiments. 6. The solvent action is somewhat retarded by the carbonic acid of the air, owing to the formation of some basic carbonate upon the surface of the zinc. 7. The decomposing and solvent action is greatest in the case of the chlorides and with potassium sulphate, weaker with the nitrates of the alkalies and of barium, and for magnesium sulphate. 8. Zinc does not decompose solutions of alkaline carbonates or sodium phosphate in the absence of air. With access of air but little zinc is dissolved by one per cent. solutions, because the zinc is protected by the zinc carbonate or phosphate formed by the reaction. In diluter solutions somewhat more zinc oxide is dissolved. 9. The action increases with increase of temperature; at the freezing point of water it is very slight. 10. Solutions of ammoniacal salts take up more zinc than the solutions of the salts of the fixed alkalies. The zinc remains bright in these solutions, and nothing separates, even if oxygen or air is permitted to enter. 11. Hard well water does not act upon zinc, even with large percentages of chlorides and sulphates. Soft water dissolves more zinc in proportion as the amount of chlorides, sulphates, and nitrates exceeds that of the carbonates and phosphates. The poisonous nature of zinc salts, even in small doses, renders the above research of more than ordinary practical interest.

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ELECTRIC LIGHTING.

BY PROFESSOR W. E. AYRTON.

(CONTINUED FROM P. 87.)

Practical Application.

We will now apply the formula developed in the last article to two very important cases, viz., illuminating by an incandescent platinum wire, and an incandescent carbon rod.

Probably no experiments have yet been made to determine the *absolute* loss of heat per unit of surface from a body of a given temperature when the difference of temperature between the heated surface and the walls of the room exceeds 100 or 200 degrees centigrade. And, in fact, when this difference is even less than 100 degrees the *accurate* information at our disposal is scanty. Fortunately, however, the law of radiation of heat is such that unless there is a total discontinuity in the phenomenon as the temperature rises we are enabled to make a very good rough estimate of what this absolute amount of radiation must be, even at very high temperatures, such as that of white hot charcoal.

Formerly, it was thought that Newton's law of cooling, viz., that the rate of loss was simply proportional to the excess of temperature, was correct; next the experiments of MM. Dulong and Petit seemed to show that in a vacuum the rate of loss was proportional to $m\,1{\cdot}0077^{\theta}\,(1{\cdot}0077^{t}-1)$ where m is a constant depending on the radiating surface, θ the temperature of the enclosure, and t the excess of temperature of the hot body; while those of Mr. Hopkins led to the result that the loss by the convective action *alone* of the gas in which the heated body was placed was proportional to $m\,p^{a}\,t^{1{\cdot}233}$ where m and a depend on the nature of the gas at a pressure p, and t, as before, is the excess of temperature.

The preceding formulæ do not, however, give results agreeing well with more recent experiments. In the Proceedings of the Royal Society for 1872, Mr. McFarlane published the results of his experiments on the absolute amount of radiation and convection from a polished or from a blackened copper ball in air. In addition to the fact that these experiments were made probably under the eye of Sir William Thomson, to whom Mr. McFarlane is an assistant, and that therefore they are probably correct, I have verified them experimentally myself, and extended them to other gases than air, and at various pressures.*

If the unit of heat be the quantity of heat required to raise one gramme of water 1 degree centigrade, and if e be the amount of heat lost per second per square centimetre of surface per degree centigrade of difference between its temperature and that of the walls of the enclosure, Mr. McFarlane found:—

Difference of Temperature.	Value of e Copper. Polished Surface.	Blackened Surface.
5°	0·000 178	0·000 252
10°	186	266
15°	193	279
20°	201	289
25°	207	298
30°	212	306
35°	217	313
40°	220	319
45°	223	323
50°	225	326
55°	226	328
60°	226	328

e, therefore, increases *less* and *less* rapidly as the difference of temperature rises. Probably, therefore, we may be safe in saying that for a difference of temperature of 1,000°C. (about the temperature of melting cast-iron) e equals 0·0003 in the first case, and 0·0004 in the second, or the absolute losses of heat per second per square centimetre of surface are 0·3 and 0·4.

From experiments made in a vacuum, I find that when the difference of temperature is under 100°C. the value of e is about half that obtained by Mr. McFarlane, and for gases like coal-gas about double.

In some of the systems of electric lighting it has been proposed to enclose the incandescent rod in a vacuum, in others in some non-decomposable gas, like nitrogen. In this latter gas I have not hitherto made absolute radiation and convection experiments, but we may fairly take as a mean value of e the air value given above; 0·0003 being used when the radiating surface is polished like platinum, and 0·0004 when it is black like carbon.

At 0°C. the resistance per cubic centimetre (p. 249 Fleeming Jenkin's "Electricity and Magnetism") for platinum is 9·158 michrohms, and from the experiments of Dr. C. Siemens (*Jour. Soc. of Tel. Eng.*, p. 297, Vol. III) this must be multiplied by 3·5 when the temperature is raised to 1,000°C. The resistance per cubic centimetre of carbon (p. 257, Fleeming Jenkin's "Electricity") is from (1,450 to 40,000) 1·616 michrohms, and from the recent experiments of M. Borgman it appears that this substance acts like an insulator, in so far that its resistance diminishes with elevation of temperature. Now our equation (1) connecting V (the difference of temperature between the centre of our incandescent rod and the enclosure) with the specific resistance, &c., is $V = \frac{C^2\rho}{K J \pi r^4} f(L, P)$ where $f(L, P)$ is such a function that it does not contain ρ or C. Now $C = \frac{E \pi r^2}{\rho L}$ where E is the electromotive force in absolute electro-magnetic units (gramme, centimetre, second) produced at the ends of our rod

$$\therefore\ V = E^2 \frac{\pi}{\rho L^2 K J} f(L, P).$$

Consequently, for a given electromotive force, the smaller be the specific resistance of the carbon employed, the greater will be the heat and, consequently, temperature produced. Of course, this is on the assumption that the heat conductivity, which is contained in P, does not vary with the electric conductivity, and this seems to a certain extent to be the case, since, while we find the electric conductivity of carbon varying between very wide limits, the heat conductivity, as far as results of experiments are available, seems to be much more constant.

At first sight it might appear inconsistent with ordinary experience to say that for a carbon rod of given dimensions the smaller the specific resistance the greater the quantity of heat developed, but it must be remembered that here we are considering a *constant electromotive force* applied at the two ends of the rod, whereas in ordinary practice it is a *constant current* we have to deal with, since when even a Grove's battery is employed to produce the current through a *short continuous* rod of carbon, the chief resistance is in the battery itself, so that the current is practically independent of changes of resistance in the carbon.

Let us take, then, 2,500 michrohms as the specific resistance at 1,000°C. of our carbon. But ρ is in absolute electro-magnetic units; therefore, since a michrohm equals 10^3 absolute units (gramme, centimetre, second)—

ρ, for platinum, equals $31{\cdot}8 \times 10^3$,
,, carbon ,, 2500×10^3.

As regards the heat conductivity, K, the values are—

For platinum ..... 0·2095.
For coke carbon ..... 0·00044.

Let our incandescent wire be about No. 20, Birmingham wire gauge, or have a diameter of about one millimetre, then $r = 0{\cdot}05$ centimetre; and let its length, L, be five centimetres in the case of the platinum and two in the case of the carbon, this longer length in the first instance being necessary on account of the better conducting power of the platinum; then we have, for

	P	Q	$\frac{Q}{P}$
Platinum	0·05728	$4{\cdot}5373 \times 10^{-13} E^2$	$7{\cdot}9214 \times 10^{-12} E^2$
Carbon	36·364	$1{\cdot}7175 \times 10^{-11} E^2$	$4{\cdot}7231 \times 10^{-13} E^2$

For the platinum, the expression

$$\frac{\epsilon^{-\frac{L}{2}\sqrt{P}} - \epsilon^{\frac{L}{2}\sqrt{P}}}{\epsilon^{L\sqrt{P}} - \epsilon^{-L\sqrt{P}}} \text{ becomes } \frac{0{\cdot}54973 - 1{\cdot}8191}{3{\cdot}309 - 0{\cdot}3022} = -0{\cdot}42218;$$

so that equation (1), which is

$$V = \frac{Q}{P}\left\{2\,\frac{\epsilon^{-\frac{L}{2}\sqrt{P}} - \epsilon^{\frac{L}{2}\sqrt{P}}}{\epsilon^{L\sqrt{P}} - \epsilon^{-L\sqrt{P}}} + 1\right\},$$

becomes $1000 = 7{\cdot}9214 \times 10^{-12} E^2 \times 0{\cdot}15564$.

Now, if X be the required electromotive force in volts, $E = 10^8 X$.

$$\therefore\ X = \sqrt{\frac{1}{79{\cdot}214 \times 0{\cdot}15564}} = 0{\cdot}2848 \text{ volts.}$$

In the case of the carbon, calculation shows that the term involving the exponential expressions is very small compared with unity. This is due to P being large, in consequence of K, the heat conductivity, being small; in fact, equation (1) reduces itself simply to $V = \frac{Q}{P}$; or, $1000 = 4{\cdot}7231 \times 10^{-13} E^2$, *i.e.*,

$$X = \sqrt{\frac{1}{4{\cdot}7231}} = 0{\cdot}46013 \text{ volts.}$$

It is, therefore, quite possible to produce a bright light with an electromotive force far less than that of a single Daniell's cell, but not, of course, with a Daniell's cell itself, since the resistance of this would be incomparably greater than that of our incandescent rod or wire.

* The results of these experiments of Professor Perry and myself will shortly be published.

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Although it requires 50 per cent. more electromotive force to maintain the centre of our two — centimetre rods of carbon at 1,000°C. than it does to maintain the centre of our five-centimetre length of equally thick platinum wire at the same temperature, it is probable that the shorter carbon rod would give out more light—first, because, in consequence of the inferior heat conductivity of carbon, the temperature curve would be flatter in the middle and steeper at the ends, so that the "surface integral" of the temperature would be higher in the case of the carbon than for the platinum; secondly, because a substance like carbon, which is black when illuminated by an extraneous light, gives out more light than a bright substance like platinum, at the same temperature, when sufficiently heated to become self-luminous, a phenomenon easily tried by placing in the flame of a spirit lamp a piece of platinum foil on which a black spot has been made with Indian ink.

In the preceding investigation no reference has been made to the value of the specific heat of the substance rendered incandescent, and reflection will show that, if a continuous light be required, the specific heat can (contrary to what has been said) have nothing to do with the question; for, if the current only produces per second as much heat as will be lost per second by radiation, convection, and conduction after the body has reached a temperature of 1,000°C., then it must necessarily reach this temperature, since at all lower temperatures it will gain more heat than it loses.

If, however, instead of a constant light, it were, for any purpose, desired that a rapid succession of lightings and extinguishings of the lamp should be possible, then, undoubtedly, it would be well to employ, for the incandescent rod, a substance having a small specific heat.

I found it not difficult, in 1873, when designing, at the request of the Government, an electric lamp for the use of the divers who recovered the property sunk in the French Mail steamship *Nil* off the coast of Japan, to make such thin carbon wires as I have spoken of in this paper. The process I employed was first to scrape an ordinary carbon rod very thin, then fix it to the two electrodes inside a glass globe from which the air could be exhausted. A strong electric current was now passed through the rod, which was burnt to the required degree of thinness by the air pumped through the globe. The current was then stopped, the air pumped out, and replaced by nitrogen, when the globe was sealed up.

Another plan I employed, on account of the fragile nature of very thin carbon, was to use platinum wire coated with carbon, and rendered incandescent in an atmosphere of nitrogen, but it was difficult to prevent the carbon coming off the smooth platinum wire.

(TO BE CONTINUED.)

THE SAWYER-MAN ELECTRIC LAMP.

The following is an abstract of an article which appeared in the *Scientific American* of Dec. 7, 1878. We give the description of the lamp merely to keep our history of the electric light complete, and from no conviction that Messrs. Sawyer and Man have made any great advance towards the solution of the problem in hand, viz., the *economical* production of the electric light for *general* purposes. It will be seen that Mr. Sawyer claims several advantages, but Mr. Sawyer can neither charge his lamps permanently with nitrogen, nor if he does will it be as effective as he states :—

"The practical usefulness of the electric light for illuminating open spaces and wide areas has been amply demonstrated by the various devices for using the electric arc already widely employed. Hitherto, however, it has not been found economical, or even possible, as we understand it, to construct a lamp or candle, based on the electric arc, that would answer the requirements of ordinary domestic and industrial lighting, where a moderate amount of light, well distributed, easily manageable, and of perfect steadiness and softness, is needed. The electric arc seems, from its very nature, to present insuperable obstacles to the economical production of a large number of small lights in a circuit; in other words, such lights as we require in our dwellings, offices, factories, shops, and the like. And if there were no other means of obtaining light from electricity, the probability of the displacement of gas by it, for the purposes of general illumination, would hardly be worth considering.

"The production of light through the incandescence of a pencil of carbon or metal, forming part of an electric circuit and highly heated by its internal resistance to the passage of the electric current, offers an entirely different field for exploration; and though it has long been apparently closed by the failure of early attempts to obtain an electric light by such means, the achieved success of Messrs. Sawyer and Man, not to speak of the reported success of Mr. Edison, clearly indicates that this is the line along which the practical solution of the problem of household illumination by electricity is to come. The lamp, to be described further on, lacks only the practical demonstration of its economy by protracted use on a large scale, to compel acceptance as a successful solution of the problem.

"So long ago as 1845, an American inventor, Mr. King, patented here and in England a lamp (said to have been invented by J. W. Starr) involving this principle. His light was produced in a vacuum, to prevent the oxidation of his incandescent carbon or metal, and was extremely promising for its beauty, brilliancy, and steadiness. But it failed to be permanent and economical from various defects and deficiencies, some of which have been removed by the increased power and economy of modern dynamo-electric machines, and by recent advances in the art of subdividing the electric current, but the most of them by the inventions and discoveries covered by Messrs. Sawyer and Man's patents.

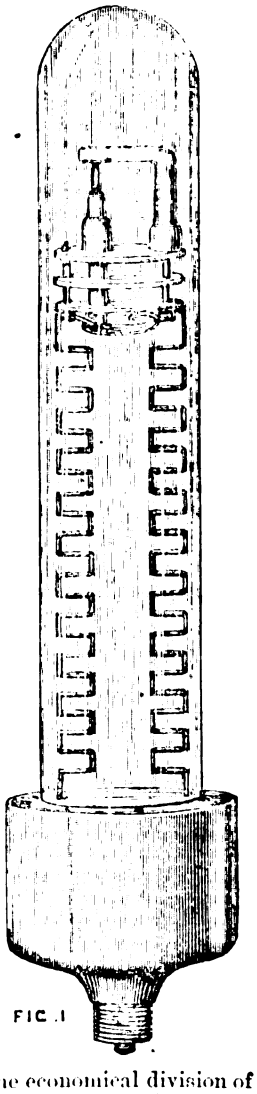

FIG. 1

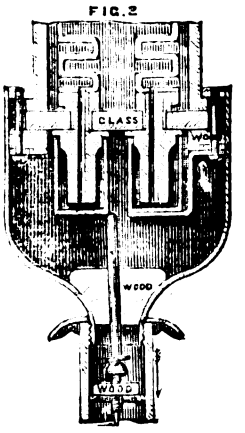

FIG. 2

"The economical division of the current, or more correctly the light produced by a single current—popularly believed to be very difficult if not practically impossible—has been successfully worked out by several American investigators. As long ago as 1875, Mr. Moses G. Farmer, now Electrical Superintendent of the U. S. Naval Torpedo Station, at Newport, R. I., subdivided the electric current, produced by a small machine, into forty-two different branches, putting a light to each branch. Mr. Sawyer's system appears to be able to do the same indefinitely through the maintenance of a uniform resistance throughout the circuit and equal resistances in the several parts of the circuit, as will be shown further on. The light produced is pure, strong, and yet soft, like sunlight. It is, moreover, steady, and cool. It is not influenced by air currents; and it does not vitiate the air by poisonous products of combustion, nor by withdrawing the vitalizing oxygen. The lamp takes up less room than the glass shade of a gas jet, and no more than the chimney of an oil lamp. To a limited extent, also, it is portable, and may be used as a drop light. The general appearance of the lamp is shown in Fig. 1. The light is produced by the incandescence of the

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slender pencil of carbon placed as shown in the engraving. The light-giving apparatus is separated from the lower part of the lamp by three diaphragms, to shut off downward heat radiation. The copper standards lower down are so shaped as to have great radiating surface, so that the conduction of heat downward to the mechanism of the base is wholly prevented. The structure of the base, full size, is shown in Fig. 2. No detailed description of this portion will be required, further than to say that the electric current enters from below, follows the line of metallic conduction to the 'burner,' as shown by the arrows, thence downward, on the other side, connecting with the return circuit. The light-producing portion is, of course, completely insulated, and also sealed at the base, gas tight.

"A fatal defect in all previous lamps depending on incandescent carbon has arisen from what has been called the 'vaporizing' of the carbon. This Mr. Sawyer holds to be an absurdity, since the carbon is not even fused. The waste of the carbon in mercurial vacuums and in atmospheres of compound gas is due, he holds, to chemical decomposition. Many gases indifferent to carbon at ordinary temperatures attack it destructively at temperatures obtained in the electric lamp; and the process is continuous, the carbon taken from the burner being redeposited on the glass case, and the gas left free to continue its depredation. Mr. Sawyer claims to have overcome this difficulty by his method of charging the lamps with pure nitrogen, and by providing for the fixing of any residual oxygen left in the lamp. In this way an unwasting carbon is secured. Another stumbling block on which other workers in this field have come to grief, has been the crumbling or disintegration of the carbon burner, due to sudden heating when the lamp is lighted. This is avoided in the Sawyer-Man lamp by an ingeniously devised switch. By this means it is impossible to turn the current on or off suddenly, to the disruption of the carbon. This, however, is not the only nor the chief advantage of the switch. It is, indeed, the key to the entire problem, the indispensable condition, Mr. Sawyer holds, of practical electrical distribution.

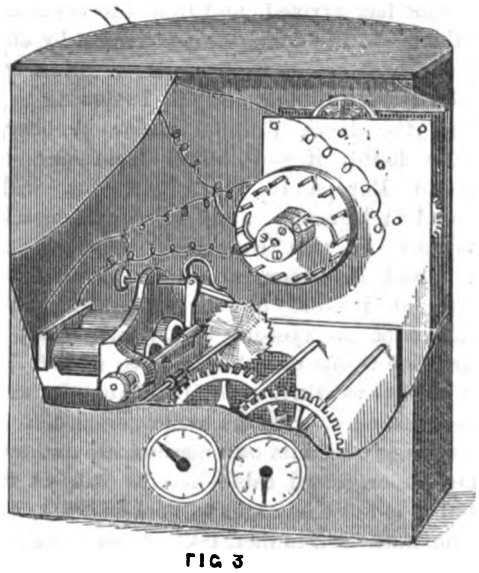

FIG 3

"It is well known that an electric current will exactly and readily divide among circuits of equal resistance. Accordingly, if the resistance of a sub-circuit be maintained constant, no matter what may be going on in it, whether a lamp is not lighted at all, or lighted to a mere taper, or to any intermediate stage up to full brilliancy, it is obvious that no other lamp or lamps in that circuit will be affected.

"The lamp has, let us say, a resistance of 0·95 of an ohm. Therefore, if one lamp is out there should be a resistance of 0·95 of an ohm in its stead. This is the shunt resistance, B. The resistance of the circuit is maintained constant at 0·95, no matter what may be the change in the proportion of the current given the lamp. The varying resistances required to give the best effect have been worked out by practical trial.

"Thus it is seen that the greater part of the illumination is the product of a small part of the current. When the light is well on, a very slight increase in the current increases the light enormously. It is here that the great loss occasioned by dividing a fixed current among several lamps finds its explanation. A current that suffices in one lamp to produce a light, say of 100 candles, will, if divided between two lamps, give in each perhaps no more than ten candles, or even five, making a loss of ninety candles in the sum total. But if the current be doubled, each lamp will give a light of 100 candles, and the sum total will be 200 candles instead of ten. Having brought a candle or a system of candles up to the point of feeble incandescence, a (proportionally) small addition to the current will make them all brilliant. If at 6,000° Fah. a given carbon will produce a light of three candles, at 12,000° it will give nine candles, and at 24,000° it will give eighty-one candles; the illuminating power increasing with vastly greater rapidity than the temperature.

"The wires supplying the current may be run through existing gas pipes, each lamp being provided with a switch placed conveniently in the wall; and by simply turning a key the light is turned up or down, off or on. So long as the house is connected with the main it makes no difference to the producer whether all the lights are on or off, since the resistance of the entire (house) circuit must be overcome; though it will to the consumer, since a meter records the time that each lamp is on, and the charge is rated accordingly. If the Dynamo-Electric Light Company can supply the illuminating force so cheaply that the constant and brilliant illumination of all the rooms of a house can be secured at no greater cost than the partial and intermittent illumination now had from gas, it is obvious that the electric light will score an important point. The cost of lamps and switches, it is claimed, will not exceed that of gas fixtures.

"The meter above referred to is shown in Fig. 3. It is a simple clock arrangement, with an attachment designed to throw the dial hands into connection when a light is on. From each switch a pair of conducting wires are run to opposite studs on the wooden disc shown at the top of the figure. When no current passes through the lamp the revolving spring shown in front of the studded disc turns without making any record. When the current is on, one electric connection at each revolution is made through the pins assigned to the particular lamp, the armature of the magnet is moved, and the recording wheel is advanced one notch. This meter does not measure the quantity of electricity passing, but only the time a lamp is on. If two or any larger number of lamps are on, an equal number of connections are made at each revolution of the wheel, and the record wheel is advanced to correspond. This registration is, of course, a mere matter of business detail. In view of the well-founded popular dislike to gas meters, however, it would seem to be desirable to dispense with such devices entirely; and the nature of electric distribution appears to favour other and less objectionable modes and means of determining the financial relations of producers and consumers.

"Where the main is tapped for a sub-circuit, a shunt is introduced so as to throw so much of the current as may be needed into the derived circuit. The resistance of say 100 added lamps will be about 100 ohms. By giving to the shunt a resistance of one ohm, 1-100th of the current will be diverted, and the lamps supplied. When a large number of lamps are required in a circuit, a combination of the two plans indicated is employed.

"The diversion of any portion of the electric supply into an added circuit, whether one house or a group of houses, necessarily increases the aggregate resistance of the electric district, and calls for more work from the generator. To meet such contingencies automatically, Messrs. Sawyer and Man have invented and patented a regulator, which responds instantly to any increase or diminution in the demand, thereby securing an absolutely uniform volume of current.

"This regulator so controls the steam or other power actuating the generator of electricity, that the amount of power supplied is increased or diminished in exact proportion to the demand, either by changing the volume of steam produced, or by coupling on or detaching different generators or parts of a single generator in circuit.

"With regard to the cost of this mode of electric lighting no positive figures can be given. It is claimed to be entirely demonstrated that one horse-power will give by the Sawyer-Man system of incandescence a light of thirty-five foot gas burners an hour. Where large powers are employed the cost of steam power, every item included, is commonly rated at one cent per horse-power per hour. The cost of 150 feet of gas, at New York rates, is forty-one cents, which would make the gas over forty-fold dearer than the Sawyer-Man light. Mr. Sawyer does not stand on this estimate, however, holding that even if the electric light should prove in practice on a large scale to be ten times as costly as calculation indicates, it will yet easily compete with gas, the light furnished being so much better and purer.

"It is promised that facilities will soon be offered for the photometric test of a large number of lights, in a circuit, with dynamometric tests of the power employed in generating the electric supply. This, as already noted, is all that the system lacks to prove itself an accomplished economical fact."

TELEGRAPHY IN SOUTH AFRICA.—We learn that a line is being constructed from Durban to Hangan, about twenty miles from the Zulu border, and near the coast.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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OVERHEAD WIRES.

Many country visitors have often wondered what was the meaning of a little tent, two or three trestles, a number of coils of dirty-brown pack-thread like material, and other paraphernalia of the staff of the Postal Telegraph Department pursuing its work in our London streets. The ordinary Londoner, however, is so accustomed to this sight, that he rarely gives it a passing thought, yet it represents a vast amount of work undertaken to a considerable extent for his particular benefit. The too obvious disadvantages, and, indeed, the immediate danger of overhead wires is every now and then brought home to us in a manner there is no mistaking. Once it is a man on the foot-board of an omnibus who is killed by the accidental breaking of a telegraph wire during a storm; again, it is a horse almost decapitated from a similar cause. It argues well for the great care taken in fixing overhead wires that such accidents happen so seldom, but the very fact of them occurring at all makes one reflect upon, and institute a comparison between, the overhead and underground wires. The telegraph department deserves great credit for having early in its career made such a comparison, and concluded that, taking into consideration all the circumstances, it was necessary that in populous centres overhead wires should be replaced by underground cables. Not only was this conclusion arrived at, but it was acted upon, and for several years the work of replacement has been gradually performed. Still, the work is not complete, and thus we are startled by the account of some such accident as took place a few days ago in Oxford-street. Had a man or woman been killed instead of a horse, we should have heard more of it, and, undoubtedly, the Department would have been severely criticised by those papers that know least of the work in progress. It may, perhaps, be a warning to the Department not to slacken its efforts to entirely replace the overhead wires by underground circuits. When, however, we consider the electrical conditions the advantages are not so obviously on the side of cables. This question has been somewhat fully discussed by the Society of Telegraph Engineers, as will be seen by a reference to the *Journal*, Nos. VI., VII., XII., XIII. Almost the last sentence uttered in the discussion therein recorded was:—"I trust the time will soon arrive when wires overhead will be a thing of the past, at least in the metropolis." We trust that we shall soon have to record that the time has arrived, and that the overhead wire is a thing of the past. The conclusion arrived at by our Telegraph Department has commended itself in other places, and France, Germany, and America are hastening to place cable circuits in the large towns. Major Webber, in 1873, said:—"No doubt, if you travel from one end of the continent of Europe to the other, you will not find underground telegraphs used to anything like the extent they are in this country." Now, we might say that the great extension of underground telegraphs on the Continent is due to our example. The overhead line is said to be an eyesore to the artist, but the ethical must give place to the useful, and were it not dangerous in snowy or stormy weather, were its insulation unaffected by atmospheric changes, or by the accumulated dirt of towns, it would continue to hold its own against all and every innovation. The underground cable may be subject to inductive action, but it is not dangerous to man or beast, its insulation is more constant, and, in fact, take it altogether, when once really understood it can be handled with better effect than its ærial rival.

Since 1876 Germany has been at work on a system of subterranean wires, and has now completed some 2,000 miles of line, at a cost of about a million pounds sterling. In Philadelphia the Pennsylvania railroad laid an experimental line which has given complete satisfaction. The insulation of this line, according to the *Philadelphia Times*, "consists in covering copper wires with cotton, laying a number of these side by side, and winding them into a cable or rope, which is pulled into iron pipes filled with paraffin oil. . . This paraffin is the most stable and durable of all known substances, not being affected by acids, alkalis, or re-agents of any kind. . . It is exceedingly cheap, there being enough wasted in the oil regions in one week to insulate all the telegraph lines in the world."

We may summarise the remarks we have made by saying that ever and anon fatal accidents occur in populous places

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by the breaking of overhead wires, that although these lines may electrically and mechanically possess some advantages over subterranean lines, they are adversely influenced by accumulated soot and dirt, and by varying atmospheric conditions; whilst cable circuits are harmless to life and limb if the wire breaks; they are, however, subject to increased inductive effects, and the laying and repairing are neither so easy nor so inexpensive as with overhead wires. All things considered, the conclusion is warranted that in large towns the overhead lines should be replaced by subterranean lines, and a consensus of opinion corroborates this conclusion, inasmuch as almost all foreign administrations are extending the latter system.

CORRESPONDENCE.

THE GOVERNMENT MONOPOLY AND INVENTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A word or two upon Mr. Herring's latest piece of evidence, and then I have done with him. His counsel's opinion bears no date, so we do not know what value he himself has practically attached to it. But we can put a valuation upon it ourselves. It removes all doubt as to the completeness of the first and, legally speaking, final trial. It is a laboured effort to give to Mr. Scudamore's subsequent act of grace and favour, assenting to a further (not a *fresh*) trial under conditions and reservations, all the force of a legal obligation. Whether Mr. Herring himself complied with those conditions seems doubtful. But, be that as it may, he received full payment for his instruments; and the verdict of impartial men will, I imagine, be that he could not claim compensation also for his "idea," inasmuch as it proved to be of no practical value. What, however, one is concerned with most is to see fair play all round; and to abuse everybody because Mr. Herring cannot have it all his own way is *not*

15th January, 1879. FAIR PLAY.

THE ELECTRIC PEN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Seeing an account of an electrical pen in No. 7, Vol 2, of *The Electrician*, it seems to me a duty to write and tell you, that five or six months ago a friend of mine, well known in the electrical world, invented a similar instrument to that of Mr. Scott's, to be used with a Rhumkorff coil. He calculated the expense of the whole apparatus at 30*s*., which is very near that given in your periodical. I have desired my friend to allow me to offer his name, but he objects, so I am only at liberty to state that in the previous issue of your periodical, he often sent communications to you under the name of "Rheostat." Of course this statement does not deprive Mr. Scott of the merit which pertains to his invention. It merely shows that there is frequently an identity of thought in the production of anything new. I enclose my card.—Yours, &c., S. GARRATT.

45, Chippenham-terrace, Harrow-road, Jan. 13th, 1879.

P.S. If absolutely necessary I can give the address of my friend.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been experimenting with the electric pen suggested by Mr. Lascelles Scott. I enclose a specimen done with it. So far as I can make it work, it is a long way behind Edison's. The faults I find with it are that the sparks are not as continous as is desirable, and they do not take the line of the pen as the sparks deviate to the right and left of the true line. I should be glad if any of your correspondents who have tried the plan can give us their experience. I fear these faults are inevitable.—Yours &c, A. PUMPHRY, Birmingham.

LIVERPOOL AND THE ELECTRIC LIGHT.

(CONCLUDED FROM PAGE 96.)

The Werdermann-Jablochkoff system is dealt with at considerable length. Some of the details given have not previously been made prominent, that they will bear extracting:—"Each Jablochkoff candle burns nominally for an hour and a-half; but as the accidental extinction of a single candle would, by interrupting the current, extinguish the other three on the same circuit, it appears to be usual to turn the commutator so as to direct the current to another candle after the last candle has burnt but little, if any, longer than an hour and twenty minutes, so that the four candles last from five hours and twenty minutes to five hours and a half. It is obvious that a larger number of candles may be fixed on each lamp if separate wires are carried up from the commutator. The cost, for which the Engineer is indebted to M. Allard, Ingénieur en Chef des ponts et Chaussées, is about 7·68 pence per candle per hour, and each naked candle is equal, according to the Société Générale d'Electricité, who are proprietors of the patent, to about 50 carcel burners, or 465 standard English candles. Photometric experiments, conducted by the Engineer, upon similar lamps supplied with electricity, in a similar manner, gave an average for the naked light of 453 standard candles when the electric candle was placed with its side to the photometre; when placed with its edge to the photometer the light was somewhat less. In this average the occasional very large diminutions of intensity lasting for short periods are not included."

With regard to the use of opal globes, the writer says that careful photometric observations have been made "which show that only 42 per cent. of the light from an electric candle, giving an illuminating power of 453 standard candles, is transmitted in a horizontal direction from the two flat sides of the candle through the globe, so that the light actually available from each lamp is less than 172 candles."

The comparison of the cost of the Jablochkoff light with gas at Liverpool is in favour of the latter. Thus, "for equal illumination of the centre line of the carriage-way in each case would, therefore, be—32 Jablochkoff candles, at 7·68 pence per hour, 1*l*. 0*s*. 6*d*.; 165 Liverpool gas jets, at 0·243 pence per hour, 3*s*. 4*d*. But such an illumination as either of these methods provides, is immensely greater than has ever before been thought desirable for permanent use. To illuminate the Avenue de l'Opéra to the same extent and at the same cost per unit of area as the best lighted thoroughfares in Liverpool, would involve the use of only forty-seven gas jets, at a cost, as before, of 0·243 pence each per hour. The total cost of lighting, according to the highest Liverpool standard, would therefore be 11·42 pence per hour. In terms of illuminating power, therefore, the electric lighting in question costs at least six times as much as illumination with Liverpool gas, while in terms of the area lighted without reference to the amount of light it costs twenty-one times as much."

The general considerations and the conclusion of the report are well worth reading, and we do not hesitate to give them complete. It may perhaps be interesting to those who are studying the question to know that it is possible to regulate the light almost at will, that is, it is possible to allow any desired number of rays to come direct from the lamp and to reflect the remainder. The method employed is, we believe, very simple, and such that practically almost the whole of the light is utilised. We shall, however, have to refer to this system in a future number. Meanwhile we have to consider the report before us. After mentioning the extension of the Jablochloff system, the Lontin light, and the Gramme machines, we read as follows:—

GENERAL CONSIDERATIONS.

"Having now referred particularly to the application of the electric light in Paris, it is desirable to consider the prospect of reducing the cost for public purposes more nearly to that of gas.

"It may at once be stated that any attempt to reduce the electric lighting of any thoroughfare to the standard of public lighting adopted in Liverpool, or even to twice that standard, would involve an expenditure so greatly in excess of the cost of lighting by gas, to the same standard, as to be quite out of the question. But admitting that in certain special cases it may be desirable to raise that standard considerably, it is important to consider how far the cost of lighting by electricity may be reduced.

"Reverting to the Avenue de l'Opéra, it was shown previously that the opal globes obstructed 58 per cent. of the light. The globes are simply used for the sake of appearance, and to avoid the great intensity of the naked light; but the latter object may be attained by reducing only those rays which reach the eye when moderately near the lamp. By a modification of the globes, therefore, the efficiency of the Jablochkoff candles may be multiplied more than twice; and by the proper use of reflectors, by which the rays which would otherwise fall on buildings and pass upwards would be directed to the darker spaces between any two lights, the efficiency may be still further increased. There is also a serious loss due to the mode of subdivision adopted, the amount of which, however, is less certain, and a loss of probably 20 per cent. arises from the use of alternating currents. Unfortunately, the only lamps hitherto applied in practice, to which none of these objections apply, are the ordinary regulators, one only being placed on each circuit, and worked by dynamo-electric machines giving currents of constant direction. Here the great

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loss from concentrated light, already adverted to, comes into play; but even this disadvantage is so far smaller than the aggregate of the others, that the same degree of illumination could be attained in such a thoroughfare as the Avenue de l'Opéra by about seven concentrated lights at less than half the present cost. The fact so often urged in Paris, 'that it would not be so beautiful,' must be freely admitted.*

"M. Rapieff, a Russian gentleman, has invented a lamp, by the use of which a partial subdivision is effected, as in the case of the Jablochkoff and Lontin systems. The electro-magnetic apparatus by which the two carbons are maintained in their position is dispensed with, and a good voltaic arc is produced between four carbons, each pair of which meet like a V, and maintain their proper distance from the other pair by mutual pressure. Several of these lamps on one circuit are in successful operation at *The Times* office. To each lamp is attached an ingenious electro-magnetic arrangement, by which the extinction of any one of the lights may take place without affecting the others. Moreover, if in one lamp the voltaic arc is suddenly broken, it is instantly re-established, as in the ordinary regulator. In this lamp, as in other regulators, a current of constant direction may be used. M. Rapieff has also taken from the Jablochkoff candle the insulating material between the two carbons, and finds that a good voltaic arc may be maintained as before. Any such simplification of the present Jablochkoff candle must materially diminish the cost.

"In all the partial modes of subdivision above described, the four, five, or at the most six lights, are placed on a single circuit in such a manner that the whole of the electricity passing from one pole of the battery traverses each lamp before it reaches the other pole. The resistance of the circuit is thereby greatly increased, and the condition of electricity known as tension, obtained by a particular arrangement of the dynamo-electric machine, is necessary in a considerable degree in order to maintain the current. The limit to the number of lights must on this account, if on no other, be very soon reached. Lights so arranged on a single circuit are said to be in *series*. But there is another mode of coupling known as *parallel circuit*. If part of a single wire circuit be cut out and any number of wires of any equal length, quality, and diameter be substituted for it, any current passed through the circuit will divide itself equally among the separate wires; but, as its strength will also be divided in the same proportion, an ordinary electric light cannot be maintained on each of the separate wires. M. Werdermann has met this difficulty by the invention of a lamp in which high tension is not required. By making the negative carbon very much larger than the positive carbon he finds that with dynamo-electric apparatus constructed for producing quantity and not tension, the two carbons may be allowed to touch, the positive carbon becoming incandescent. In this lamp it appears only to be necessary to secure a constant current of the right kind and a constant amount of pressure of the positive carbon against the negative carbon. As each lamp has its independent current, its extinction can only brighten the others. This light has hitherto only been applied experimentally, but it is about to be employed for the illumination of the space in front of the London Exchange and Bank of England.

"The Engineer has, however, examined the system in the works in London, where two naked lights, each stated to have an illuminating power of 320 candles, or 10 naked lights of 40 candles each, are produced by two-horse power. The candle power and the motive power are given as stated by M. Werdermann. The Engineer believes them to be correct, but he had no means of verifying them. In this, as in all systems of subdivision, there is considerable loss, as is shown by the fact that the power which will produce 640 candles in two lights will only produce 400 in 10 lights.

"As the production of light depends upon the resistance at the point to be illuminated being much higher than in any other part of the circuit; and as, by allowing the carbons to touch, the former resistance is much reduced, the remaining resistance must be kept down by increasing the size of the conducting wires, and this is an element of increased cost.

"It remains to be seen whether or not M. Werdermann will succeed in making the cost of his system cheaper than the systems of division in series; but it is certain that he has produced ten perfectly steady lights of only forty-candle power each from a small electro-plating machine—a result which appears to be a most important advance in the practice of electric lighting.

"Some time past the English papers contained accounts of an invention by Mr. Edison, of the United States, for sub-dividing the electric light, but the Engineer has been unable to obtain authentic particulars of the improvements in question.

"The Engineer has referred almost exclusively to the use of the electric light for exterior illumination. For the lighting of public halls, however, it has peculiar advantages. The light, if properly diffused and sufficiently brilliant, is very like daylight, and the vitation of the air is scarcely appreciable.

CONCLUSIONS.

As indicated in the foregoing report, the Engineer is of opinion:—

"1st. That the cost of the only system of public lighting by electricity at present in use is six times the cost of Liverpool gas, producing the same degree of illumination and twenty-one times the cost of the Liverpool gas which would, under ordinary circumstances, be consumed in the illumination of the same area.

"2nd. That the great discrepancy in the cost of public electric lighting in Paris and of public gas lighting in Liverpool, is due in a high degree to the fact that the agreeable effect produced by a succession of large semi-opaque globes, equally illuminated, has been regarded as the first consideration.

"3rd. That apart altogether from the palpable loss produced by the opal globes, there are further losses of a very serious kind which are not common to some other existing methods.

"4th. That it is obvious, from dynamical considerations, that the electric light, when subdivided, will always give a less candle power for the same expenditure of mechanical energy than when concentrated; but, with the materials at present available, it is impossible to say whether that loss will always be so great as to leave the concentrated light, treated in the best manner, more economical than the divided light for public illumination.

"5th. That the spaces, north, east, and west of St. George's Hall, Liverpool, are well adapted for illumination by electricity, and as a new engine has lately been erected in the basement of the hall for pumping to the Steble Fountain, the Engineer recommends that such dynamo-electric machines to be driven by that engine, be obtained as will enable the Corporation to make a fair trial of various systems for the illumination of the spaces in question. Estimates have been obtained from the various makers for the supply of the necessary apparatus.

"In such comparative trials the practical effect of the lights may be estimated by the public, but the power of the engine should be measured by a dynamometer, and the power of the lights by a photometer. The Engineer will then be enabled to report exactly as to the relative cost of gas lighting, and of the various systems of electric lighting when applied in the most economical manner in Liverpool. He has little doubt that a very considerable reduction upon the cost in Paris may be effected.

"GEORGE F. DEACON, M. Inst. C.E."

* Since writing this report the Engineer finds that the subject of efficiency of concentrated lights, with proper reflectors for public thoroughfares, is receiving the attention of Dr. Siemens, F.R.S., whose exertions in this direction may shortly be compared in practice with those of the many inventors who are improving the various methods of sub-division.

ALLAN AND BROWN'S LARGE SENSITIVE RELAY AND PATENT CABLE RELAY.

This relay, the result of a great deal of experience and experiment, has supplied a want long felt, particularly on cables that exceed 200 miles in length, where Morse working was desirable, or unavoidable. There have been numerous cables worked for years on the Morse principle at a comparatively slow rate of speed, say nine or ten words per minute, much to the disadvantage of the companies which owned them, not only through the great and serious delays which frequently occurred to the traffic, but also on account of the many errors which must necessarily occur when an instrument not really adapted to the work required of it is pressed to the maximum speed at which it will respond. It is impossible to obtain thoroughly good work from any instrument unless there is a certain margin or reserve of capacity. Few persons would think of getting the regular traffic through a cable at the same speed as might be obtained during a trial. Now, if the length and conditions of a cable are such that the trial speed of the best Morse relay is reduced to twelve words a minute, the ordinary working speed would not be much more than eight; this rate is most inconvenient in several ways. Very few of the clerks send well when working so slowly; there is no freedom or ease in the manipulation, and at certain hours the work must be greatly delayed.

The Allan and Brown relay by means of its sensitiveness, peculiar construction, and particular adaptation to cable working obviates all these evils. It increases the speed fully 125 per cent., is quite as easy to work, and no more likely to get out of order than the instruments now in use. Its principal point of excellence is, of course, the great increase in speed; but there are others, such as the marked uniformity of the signals, the little attention required for regulation, the small power which may be used, &c.

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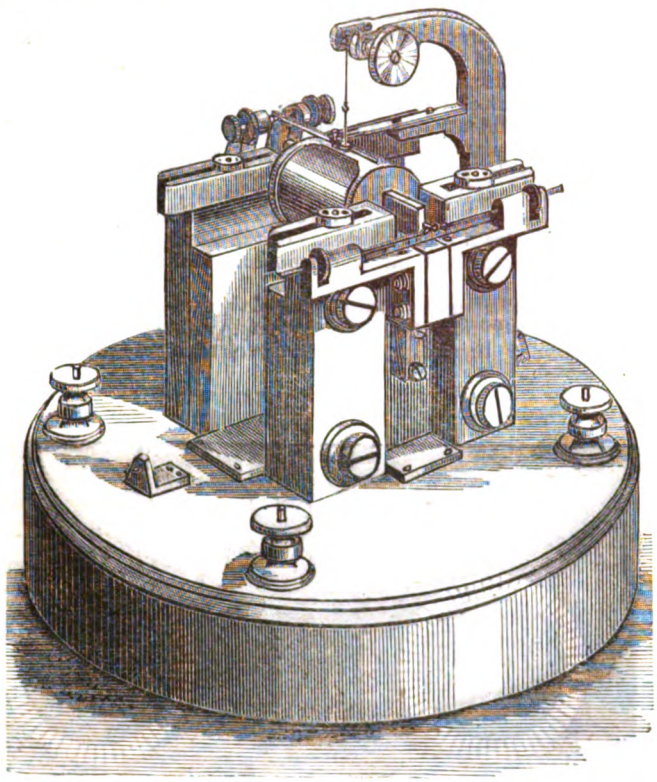
The Porthcurnow and Vigo section, 620 miles, could not be worked practically with an ordinary relay, yet a speed of twenty-six words per minute is obtainable with the "Allan and Brown."

This one fact in itself is all that is necessary to recommend the instrument to all companies upon whose lines it might be placed with advantage.

The "Direct Spanish" Company, who have been using the relay for several months, increased their speed through nearly 500 miles of cable, from twelve to twenty-seven words per minute. Formerly the "Mirror" was always kept in readiness as a reserve, and used during any particularly busy time, the ordinary Morse being totally inadequate, but since they have been using the "Allan and Brown" the "Mirror" has, for speaking purposes, been abandoned.



The following is a description of the best form of the instrument in use, and is referred to in Sir James Anderson's letter as the "large sensitive cable relay."

An electro-magnet, A, of proper form and dimensions, is suspended between permanent magnets, NSNS, free to move when excited to right or left as far as the compensating springs BB' attached to one end of its core will allow. It is obvious that these springs will only permit this electro-magnet to move to a point where the potential of the current and the tension of the springs balance each other; and the electro-magnet—or, as it is often termed, moving coil—will truthfully follow the pulsations of the received current in a natural manner.

On top of this moving coil is loosely pivoted a contact arm, C, generally called a "jockey armature," which, being light and placed in the most favourable position, opposes only the friction caused by its weight to the free movement of the coil, this opposition practically amounts to little or nothing. A local circuit made through this "jockey" would be closed the moment the coil moved, and would remain closed as long as it continued to move in the same direction; but the instant a fall of potential took place, and the coil, through the action of the springs receded, no matter how little, the local circuit would be broken; therefore, it is possible to obtain *arbitrary* characters, such as the Morse, on a rise or fall of potential, instead of having to bring the line or cable current to "zero."

Regarding the regulation and working of the instrument, experience on the particular circuit worked is the best teacher. The following hints, however, will, probably, not come amiss :—

The weight of the "jockey" gives friction enough for contact purposes, the spiral on the centre pivot being seldom used. An increase of friction means so much more opposition to the free movement of the coil, and is detrimental in proportion.

There are local contact points, *d d'*, on *each* side of the "jockey;" either may be used, or both should it be desirable to have a reverse current in the local circuit.

The local contact points should be adjusted so closely that no motion of the "jockey" is visible, sufficient to make and break the local circuit being all that is required.

The compensating springs should be adjusted so as to ensure the greatest amount of elasticity, *i.e.*, rather stiffly.

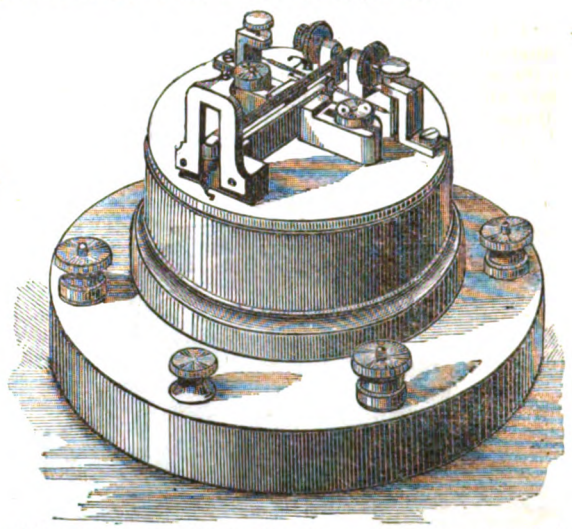
The electro-magnet of the inker, or whatever local instrument is used in direct connection with the cable relay, may be "shunted" with a condenser of say, 10 microfarads. This is to avoid the spark at the point of contact on the "jockey."

A little experience will soon show the best adjustment for the permanent magnets.

The whole secret, if secret it may he called, of the success of this relay is the fact that it contains what is technically known as a "moving zero." All other relays at present in use have "fixed" or "dead zeros." No instrument can be worked with any reasonable speed or success through cables over 300 miles which does not contain this quality of a "moving zero."

The "Thompson Mirror" and "Recorder" and the "Allan and Brown" relay all contain this element, therefore their greater success and value.

On cables of 300 or 400 miles this "jockey" armature can be attached with advantage to any existing instrument, such as a Siemens or other relay (Fig. 2), and the alteration will increase the speed certainly to the extent of 100 per cent.



The following letter from Sir James Anderson, managing director of the Eastern Telegraph Company, who have over 50 of the relays now at work on their cables, explains itself :—

"London, 21st March, 1878.

"G. Allan, Esq., C.E., 18, Leadenhall-street.

"Dear Sir: In reference to the Allan and Brown relay, I am happy to be able to assure you that we have adopted it as *the* instrument upon all the short sections of our system.

"It is, beyond all doubt, the best relay we have ever tried or heard of.

"I have ascertained recently the trial speed upon several of our short cable sections with this relay, and state it as follows :—

Zante to Otranto,	187	miles,	28	words	per minute.
Alexandria to Sitia,	360	,,	25 to 30	,,	,,
Marseilles to Bona,	447	,,	25	,,	,,
Gibraltar to Lisbon,	364	,,	25	,,	,,
Porthcurnow to Vigo,	620	,,	26	,,	,,

"This latter being the large sensitive cable relay, we have ordered these instruments for all our stations in the Levant.

"I may add further that upon our land lines between Marseilles and London, and Porthcurnon and London we are enabled to work by using this relay at times when it would be impossible to work with the ordinary relays hitherto in use.—Yours truly,

"(Signed) James Anderson, Managing Director."

London, August 29th, 1878.

THE PHONIC WHEEL OF M. PAUL LACOUR, OF COPENHAGEN.*

(Exposition Universelle of 1878.)

(concluded from page 89.)

Application for the registration of velocities.—The phonic wheel may be applied also as a counter in measuring the velocity of other movements, and for this purpose it is requisite only to cause it to act synchronously with these movements. As it is

* Translated from *L'Electricité*.

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provided with a registering apparatus, the velocity of the movements can be immediately ascertained. Suppose we wish to know the velocity of a wheel in a machine, we fix to its axis a toothed wheel having the same number of teeth as the phonic wheel, and we use the former as an interruptor. The phonic wheel will at once move synchronously with it.

If the velocity to be measured be too great to allow of its corresponding with that of the phonic wheel, a groove may be made in the axis, allowing of a contact at each revolution, which will then be denoted by a single tooth of the phonic wheel. M. Lacour enumerates as follows the advantages of this arrangement:—

"1. The phonic wheel employed as a counter moves equably, and not by jerks; it thus offers, at a distance if requisite, a faithful representation of the movements of the machine.

"It can never *miss*, since it is physically impossible that a single tooth of the wheel should be "skipped" without the wheel stopping altogether.

"3. It can count with much greater rapidity than the most rapid counters now in use."

Application in Telegraphy.—One of the most important applications of the phonic wheel is, without doubt, its use in those telegraphic systems which require perfectly synchronous movements, such as the printing instruments of Hughes and the multiples of MM. Meyer and Bandot. Up to the present time these combination systems are very complicated and delicate; and it is always, even at the present day, the mechanisms employed to regulate the synchronism that are at fault. With the phonic wheel, the solution of the problem will be much more simple. Figs. 11 and 12 show how the phonic wheel should in this case be arranged.

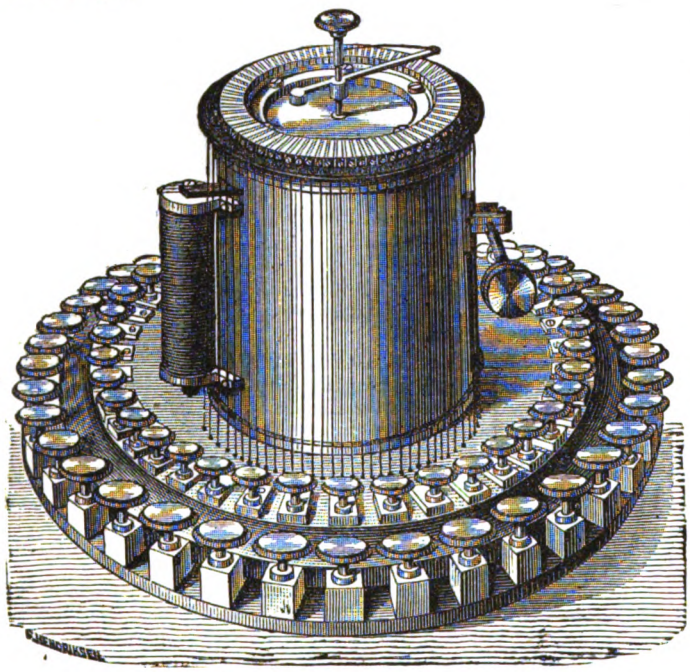

Fig. 11.

A brass support, Fig. 11, carries on its upper portion an ivory wheel, in the surface of which are sunk sixty equal, equidistant, and insulated metallic plates. By means of conducting wires, these plates are connected to sixty binding screws fixed to the base of the apparatus, where they are arranged in two circles at different levels, so that the plates communicate alternately with an upper and a lower binding screw. These plates have a smooth surface, on which slides a revolving friction piece, mounted on the axis of a phonic wheel with thirty teeth, and which is placed beneath the brass disc, concentrically with it. To the left may be seen the acting electro-magnet, the poles of which traverse the support of the apparatus, and are brought into proximity with the phonic wheel.

Fig. 12 represents two stations at which two systems of this description have been established. The sending station is at A, and the receiving station at B. At the former, the diapason transmits phono-electric currents to the electro-magnet of the phonic wheel at *u*; and the revolving friction piece *o*, touching in succession all the plates 1, 2, 3, 4, &c., sends alternately through the line-wire the currents of the two batteries *r* and *s*, which, being connected with the even and odd plates by poles of opposite sign, furnish charges which are alternatively negative and positive.

At the arrival station, these currents, after having traversed the electro-magnet *m m*, and set in action the electro-magnetic system of the phonic wheel B, are conducted to the support of the latter and consequently to the friction piece *p*, which transmits them to the plates, and causes them to pass to earth at *j*. Now since, in traversing the electro-magnet *m m*, these phono-electric currents maintain in synchronous and continuous vibration the diapason *β*, which vibrates under exactly the same conditions as the diapason *a* at the sending station, and which causes the wheel B to turn synchronously with the wheel A, the friction piece *p* passes over the plates 1, 2, 3, &c., at station B exactly at the same moment as the friction piece *o* passes over the corresponding plates at station A; and the current can act successively on different apparatus in connection with these different plates.

This arrangement further allows of the negative and positive waves being separated and made to produce the effect of distinct currents in opposite directions. In fact, if the odd plates be brought into contact with a galvanometer, before the circuit is taken to earth at *j*, the series of negative waves will produce a continuous deflection in a determinate direction, which will be opposite to that of the deflection produced by similarly connecting the even plates to earth through the instrument.

By acting upon the electro-magnet of the phonic wheel at B, it is possible, by suitable adjustment, to obtain a maximum deviation, which will then indicate that each positive or negative wave passes wholly or mainly through the even or the odd plates. This constitutes not only a means of regulating the synchronism of the two apparatus, but also one for obtaining the maximum effects of the current.

In order to bring the homologous plates into connection when the apparatus is adjusted, one may employ at the arrival station a commutator furnished with thirty conductors, which are in

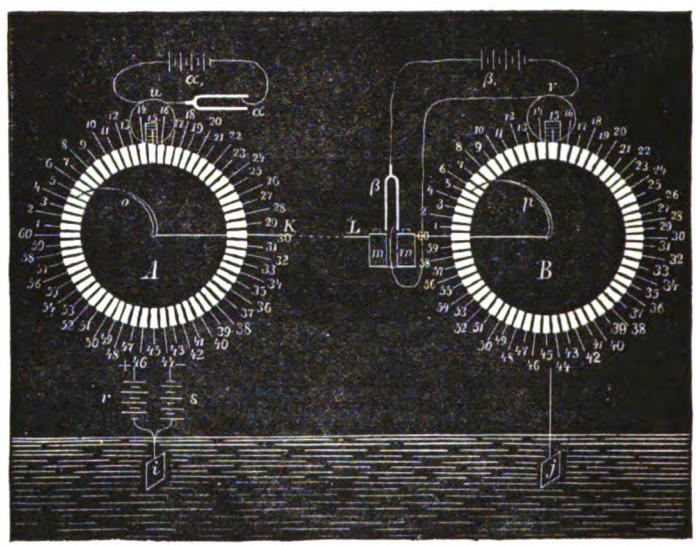

Fig. 12.

communication on the one hand with the thirty even plates of the phonic wheel B, and on the other hand with the thirty telegraphic instruments which it is intended to work; and it is brought successively on to the different contacts until the currents sent by one of the transmitting instruments arrives at the receiving instrument with which it is intended to correspond. Under these conditions the commutator will produce the same effect as if the friction piece *p* had been taken by hand to the plate which corresponds with that touched by the friction piece *o* at the same moment.

One may, therefore, by this system, transmit from the sending station, through the intermediary of thirty instruments, signals which will be reproduced by the same number of instruments at the arrival station; and each of these instruments can transmit as many signals per second as the number of revolutions made by the phonic wheel in the same space of time.

Application to Scientific Researches.—If we wish to study any phenomenon manifesting itself at a given moment of the period of transmission of an electric wave, as, for instance, the force of a phono-electric current at different moments of its emission, the phonic wheel can readily supply the requisite indications. It is only necessary for this purpose to arrange an insulated contact piece, so that the teeth of the phonic wheel may touch it at the moment when the phenomenon is to be observed. By making

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the current pass through this interrupting system, we may obtain a derived current that can readily be studied, and which corresponds to that phase of the wave which has to be considered.

In virtue of its uniform motion, the phonic wheel can serve to measure or to represent graphically the velocity of rotation at each moment of any apparatus or machine.

"There are several methods of proceeding," says M. Lacour. "The following is a very simple one. The axis of a phonic wheel maintained in regulated movement by means of a diapason, carries a thin black disc, perforated with equal and equidistant holes, arranged in the form of several concentric circles, ten for instance, of which that which is nearest the centre contains five holes, the next ten holes; and so on up to the tenth circle, which will contain fifty holes. When we look down upon a white surface through this revolving disc, the circles appear as circular zones of a grey colour, and concentric, as shown by Fig. 13.

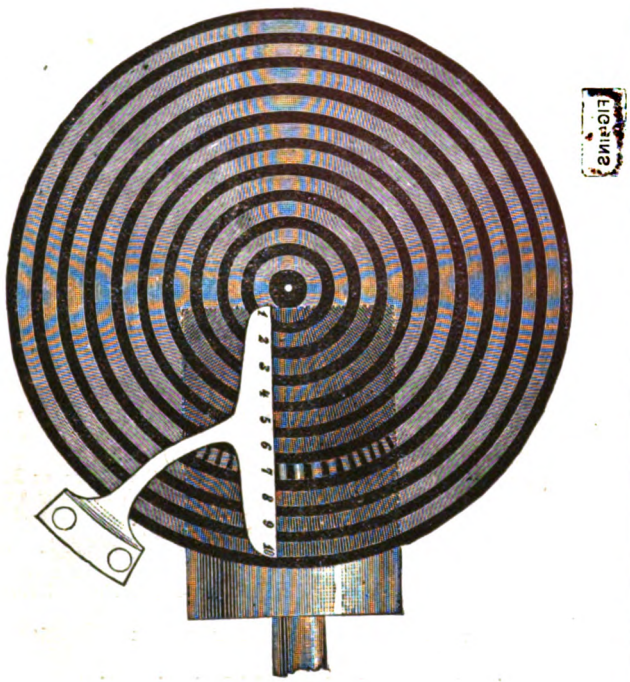

FIG. 13.

"On the other hand, the machine of which the velocity is to be measured produces the rotation of a cylinder which is painted with black and white stripes, of equal breadth, parallel to its axis. This cylinder, which appears of a grey colour, is situated beneath the disc which has been described. If the machine possess a velocity capable of making the cylinder advance by thirty-five stripes, for instance, for every rotation of the phonic wheel, the seventh zone of the disc will show the black and grey bands motionless, as shown in the figure, and for reasons which have been considered above. If the velocity of the cylinder augment slightly, the bands will be seen to move in the direction of the rotation of the cylinder, and the faster the latter turns, the more rapid will seem to be this motion of the bands. Let now the velocity continue to augment; we shall then see in the eighth zone other bands which, commencing with a rapid motion in the direction opposite to that of the former bands, gradually slacken (as the bands in the seventh zone move faster and faster), and finally remain at rest. The machine will then have a velocity capable of making the cylinder advance to the extent of 40 black stripes for every rotation of the phonic wheel.

"The application of the apparatus is very simple. The zone which exhibits the stationary bands is at once perceived, and the velocity of the cylinder is proportionate to the corresponding number which is inscribed upon a fixed scale with which the apparatus is provided. Should two zones show bands apparently moving in contrary directions, the velocity of the cylinder is somewhere between those corresponding to these two zones. This method thus allows of the direct observation, at any moment, of the velocity of the cylinder, and of any variations of this velocity."

The arrangement of apparatus represented by Fig. 11 will allow of numerous and important researches on the phenomena of induction, static charges, the velocity of electricity, and the determination of geographical longitude.

TH. DU MONCEL.

THE ELECTRIC LIGHT.

Mr. Louis Schwendler has made a long series of experiments on the electric light, in order to report upon the advisability of adopting it for the lighting of Indian railway stations. The report is exceedingly valuable, but is too long to give complete. The following is taken from the *précis* of the report, and will, doubtless, prove interesting to the large number of readers who are studying the phenomena of the electric light. We shall in future issues refer to the machines tried and methods used.

RESULTS.

Economy of the electric light.—The energy of the standard candle was ascertained by *direct experiment*. It was found that the standard candle, in order to produce the unit of light, does work at the rate of 610 meg-ergs per second *at the least*. In fact, it is highly probable that the standard candle, in order to produce the unit of light, works up to more than double that amount (1,365 meg-ergs per second).

Further, by direct experiment, it was ascertained that the unit of light, as produced in an electric arc, by any one of the dynamo-electric machines under trial, and through a leading wire offering not more than 0·1 S.U. resistance, is produced at the rate of not more than 20 meg-ergs per second, including *all the work transmitted*, and the light measured in a line which passes through the centre of the arc, and stands normal to its axis. Hence the probable engineering margin in favour of the electric light is between 30 to 70, or equal to a mean of 50.*

Dynamo-electric machine A produces the unit of light at a rate of not more than 10 meg-ergs per second. Hence it may be safely asserted that the electric light produced by dynamo-electric machines is, as an average, 50 times cheaper than light by combustion. This is, however, true only as long as the light is produced in *one* arc. If more than one light is produced in the same circuit by the same current, the external or available light becomes rapidly dearer with increase of the number of lights produced. For this reason already, if not for many others, the *division of light* must result in an engineering failure. It is in the nature of the electric light that it should be used in *great* intensity in *one point*, instead of small intensities in *many* points.

Current produced by dynamo-electric machines.—These currents, as the insertion of a Bell telephone (used as a shunt) will easily prove, are *not steady*. The dynamo-electric machine with the greatest number of sections in the induction cylinder gives the steadiest current. Twelve sections I find *necessary* and *sufficient*.

Influence of speed.—The current produced by any dynamo-electric machine through a given constant total resistance in circuit increases permanently with the speed of the induction cylinder. This increase of current for low speeds is more than proportional to the speed; afterwards it becomes proportional, and for high speeds the increase of current is less than proportional to the speed. The current has, however, no maximum for any speed, but reaches its greatest value at an infinite speed. This same law, as the total resistance in circuit is supposed to be constant, of course holds good also for the electromotive force of the dynamo-electric machine.

Influence of external resistance.—Keeping the speed constant, the electromotive force of any dynamo-electric machine decreases rapidly with increase of external resistance. This decrease is more rapid the smaller the internal resistance of the dynamo-electric machine is made. Hence the currents must decrease much more rapidly than proportional to the total resistance in circuit. As in the case of speed, the electromotive force has no maximum for a certain external resistance, but approaches permanently its greatest value for an external resistance equal *nil*. It appears that the function which connects E.M.F. and speed is the same as that which connects E.M.F. and external resistance. We have only to substitute for speed the inverse of resistance, and *vice versâ*.

Maximum work by a current in the resistance r.—As the current decreases much more rapidly than the total resistance in circuit increases, this resistance r should invariably be made *smaller* than the remaining resistance of the circuit, *i.e.*, smaller than the internal resistance of dynamo-electric machines plus resistance of leading wires.

The electromotive force of a dynamo-electric machine as a function of the resistance and speed.—It appears that the following two formulæ are most probably correct for *all* dynamo-electric machines if the loss of current by transmission is taken into account:—

$$E = \kappa \left\{ 1 - \frac{1}{e^{\left(\frac{a}{m+r}\right)^2}} \right\}$$

* A refers to a Siemens machine *medium* size.
B ,, ,, *small* ,,
C ,, Gramme machine workshop pattern.
D ,, ,,

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E the E.M.F., m the internal resistance, and r the external resistance, including resistance of leading wire. κ and a are independent of m and r, and are functions of the speed of the induction cylinder, and contain also the construction co-efficients. c is the basis of the natural logarithm. Further—

$$E' = \kappa' \left\{ 1 - \frac{1}{c^{\left(\frac{v}{a'}\right)^2}} \right\}$$

E′ the E.M.F., and v the speed of the induction cylinder. κ' and a' are independent of v, and are functions of m and r only. These two functions, E and E′, correspond to all the characteristics of the curves found by experiment, and they also fulfil the limit conditions.

Resistance and electromotive force of the electric arc.—There appears to be no doubt that an appreciable E.M.F. in the arc is established, which acts in opposite direction to the electromotive force of the dynamo-electric machine. This E.M.F. of the arc *increases* with the current passing through the arc. The resistance of the arc for constant length is also a function of the current passing through it, *i.e.*, the resistance of the arc *decreases* with the current (see the following table):—

Current in Webers.	Resistance of the Arc in S.U.	E.M.F. of the Arc in Volts.
28·81	0·91	2·02
23·87	1·72	1·91
16·27	1·97	1·86

The E.M.F. in an electric arc, opposite to the electromotive force of the dynamo-electric machine, constitutes another reason against the unlimited divisibility of the electric light.

Regularity of the production of currents by dynamo-electric machines at different periods.—If the brushes are well set, and if they are placed as nearly as possible in the neutral line of the commutator, the production of current is perfectly regular, and measurements taken through the same external resistance at the most distant periods agree most perfectly with each other, supposing the correction for variation in speed and internal resistance are applied. Disregarding the heating of the dynamo-electric machine by the current, the time required to arrive at dynamic equilibrium, *i.e.*, when force transmitted, current, and magnetism received are constant, is very short indeed, especially for the strong currents, which alone are made use of for lighting.

Formula for controlling the test-results.—As the power which is represented by the measured current working through a given resistance can never exceed the original power transmitted to the machine, we can, from current, resistance, and force measurements, frame a formula which checks the probability of the results. This formula is:—

$$C \leqq 0{\cdot}33 \sqrt{\frac{W' - w'}{r + m}}.$$

W′ is the *total power* consumed by any dynamo-electric machine when producing the observed current C in a circuit of resistance $r + m$; w' is the power consumed by the dynamo-electric machine when producing *no current* (*i.e.*, driven empty, circuit open, external resistance infinite); r is the external resistance, and m the internal resistance. In the above formula C is in Webers, W′ and w' in meg-ergs per second, and r and m in S.U. Of late, exaggerated statements of the performance of dynamo-electric machines have been made, the absurdity of which would have become evident at once if the above formula had been applied as a check to the results.

(TO BE CONTINUED.)

RECENT PATENTS.

1932. Galvanic Batteries and Electrical Apparatus, *W. Scantlebury.—Dated 14th May*, 1878.—(*Not proceeded with.*) 2*d*.

The carbon plates of fluid batteries are perforated so as to cause the exciting fluid to circulate. Instead of mounting induction coils upon a base board, the edge of the condenser is attached to the coil so as to occupy very little space.

1937. Coating Telegraph Wires, *W. Abbott.—Dated 15th May*, 1878. (*Not proceeded with.*) 2*d*.

The wire coated with any ordinary insulating material is covered with a plait or braid of cotton or other yarn impregnated with the residuum from the distillation of ozokerite as described in patent No. 1087, dated the 17th March, 1877.

1988. Phonic Wheels, &c., *P. Lacour.—Dated 17th May*, 1878. 6*d*.

This consists, First, in the construction and arrangement of a magnetised reed or tuning fork, which is kept in vibration by the action of two electro-magnets, one on each side of its magnetic poles. Secondly, in the construction and arrangement of a toothed wheel and electro-magnet, the intermittent current or pulsation of which is regulated by the device above mentioned, and any given number of which—each forming a part of the movement to be brought into synchronous action with the initial or principal isochronograph—may be operated synchronously, or in perfect unison by a single regulator.

2003. Apparatus for the Generation and Application of Electricity for Lighting, Plating, &c., *H. J. Haddan.—Dated 18th May*, 1878.—(*A communication.*) 1*s*.

This consists in the construction and use of annular metal armatures grooved on their peripheries or sides, or both, and insulated partly or entirely from each other. Also in constructing commutators cylindrical with an insulated hub or body, to which are attached metallic sub-segments placed in electrical connection with the general mechanism in which the commutator is employed, and metallic wearing segments detachably attached to said sub-segments. Also in supplying dynamo-electric machines with a wire or helix having a high resistance, and keeping the same in closed circuit while the machine is running in combination with the magnet wire or helix usually employed. Also in an electric lamp or regulator, the combination with the usual carbon holder and core of a clamp surrounding the holder, and of an adjustable stop, said clamp being independent of the core, but adapted to be raised by a convenient lifter secured thereto, whereby the holder is firmly held and permitted to accurately feed the carbon points as the same are consumed; and by means of the stop said points are prevented from becoming too far separated.

2008. Scenic Effects, &c., *J. N. Aronson.—Dated 20th May*, 1878.—(*Not proceeded with.*) 2*d*.

The scenery is dressed with Geissler or vacuum tubes, which are connected with the source of electricity.

2033. Electro-motors. *A. M. Clark.—Dated 21st May*, 1878.—(*A communication.*)—(*Not proceeded with.*) 2*d*.

This consists in the combination of a series of adjustable permanent magnets and a wheel carrying a series of electro-magnets, and a current changer that alternates the current without absolutely breaking it, and after passing the poles of the said permanent magnets are repelled, the current being changed at the proper instant.

2137. Telegraph Signalling Apparatus for Increasing the Speed of Working Telegraph Cables, &c., *F. Trimmer.—Dated 29th May*, 1878.—(*Not proceeded with.*) 2*d*.

Combined with any key used in connection with the Morse or Mirror systems of working is one or more electro-magnets with armatures which are actuated by a local battery or the working battery. The electro-magnets are governed by and follow the movements of the key, and their action is so regulated that at the proper moment of time during or between the formation of each signal the current passing through the line to the distant station is either reversed, weakened, cut off, or shunted from the circuit.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Jan. 15.		Business Done Week Ending Jan. 15. Highest.		Lowest.	
Anglo-American	58¼,	59		59		58
Do. "B"	84¼,	¾		85		83¾
Do. "A"	34½,	34		34¼		32¾
Brazilian	6½,	¼		6 11-16		6 9-16
Cuba	8¼,	¾		—		—
Do. Ten per Cent. Preference	15½,	¾		15¾		15¾
Direct Spanish	1¾,	2		—		—
Do. Ten per Cent. Preference	9½,	10½		—		—
Direct United States	11¼,	¼		11¼		11¼
Eastern ex div.	7¼,	⅜		7 7-16		7¼
Do. Six per Cent. Debenture	104,	107		105¼		105¼
Do. Five per Cent. do.	101,	104		—		—
Do. Six per Cent. Preference	10⅞,	11¼		11¼		11
Eastern Extension	7 1-16,	3-16		7¼		7¼
Do. Six per Cent. Debenture	104,	106		—		—
German Union	8,	½		—		—
Globe Telegraph and Trust	5,	⅛		5 1-16		4 15-16
Do. Six per Cent. Preference	10¾,	½		10¾		10¾
Great Northern	7⅜,	⅛		7¼		7¼
Indo-European	19,	20		—		—
Mediterranean Extension	2¼,	3¼		—		—
Do. Eight per Cent. Preference	9,	¼		—		—
Reuter's	10,	11		—		—
Submarine	217,	222		220		218
West India and Panama	1⅞,	2¼		2		2
Do. Six per Cent. Preference	8,	¼		8 3-16		8 3-16
Western and Brazilian	2⅛,	⅜		—		—
West. Union Seven per Cent. 1st Mort.	114,	118		—		—
Do. Six per Cent. Sterling	101,	103		—		—

TRAFFIC RECEIPTS FOR DECEMBER, 1878.

Companies.	Dec. 1878.	Dec. 1877.	Increse.	Decrse.
Anglo-American Telegraph Company	47,040	45,570	1,470	—
Brazilian Submarine Company	14,231	12,318	1,913	—
Cuba Submarine Company	2,800	2,666	134	—
Direct Spanish Telegraph Company	939	857	82	—
Direct United States Telegraph Company	13,970 estd.	12,930	1,040	—
Eastern Extension Telegraph Company	22,929	23,980	—	1,051
Eastern Telegraph Company	38,467	37,777	690	—
Great Northern Telegraph Company	14,803	—	—	—
Submarine Telegraph Company	8,498	8,754	—	256
Western and Brazilian Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	5,304 estd.	4,558	746	—

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NOTES.

THE DEVASTATION.—This double turret ship, at present undergoing a refit at Portsmouth, is ordered by the Admiralty to be provided with the electric light.

COPPER-ZINC COMPARED WITH PLATINUM-ZINC ELEMENTS.—Prof. Jacobi, writing in 1841, said that a battery containing six square feet of platinum surface was equivalent to one containing one hundred square feet of copper surface.

EASTERN TELEGRAPH COMPANY (LIMITED).—The thirteenth ordinary meeting of this Company will be held on the 30th inst. at two o'clock at the Cannon-street Hotel. An abstract of the report will be found in another column.

MAGNETIC OBSERVATIONS.—In 1828 Baron Humboldt laid the foundation of the German Magnetic Association by erecting a magnetic observatory at Berlin, which proved to be the pioneer of others in various parts of Germany and Russia.

GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).—It is notified that the transfer books of this Company will be closed from the 1st to the 7th of February, and that an interim dividend of 7 per cent. is to be paid on the preference shares, and 4 per cent. on the ordinary shares on or after Feb. 7.

THE VOLTAIC PENCIL OF M. BELLET.—According to *l'Electricité*, means have been found to engrave upon stone or metal by the effect of a voltaic arc produced from the point of a pencil. It is said that, by these means, an artist can himself reproduce, immediately and without the intervention of any skilled workman or mechanic, the most delicate and complicated designs. If this statement can be confirmed, it will be of no small interest to the proprietors of illustrated papers.

ESCAPE OF A BURGLAR BY A LIGHTNING CONDUCTOR.—According to the daily papers, a notorious burglar has just been captured, who, two years ago, on being chased, ran into a church, and, mounting to the tower, escaped by sliding down the lightning conductor. Perilous as such a freak must appear, it nevertheless points to a necessity of rendering conductors inappropriate for such purposes, for though, perhaps, the ascent may have been a very different task, it is not impossible that a determined thief may gain access to a building by a lightning rod. It may be of sufficient interest to telegraph engineers, when erecting a conductor, to remember that a "path to electricity" has at least once conducted a thief safely out of the reach of his pursuers.

LIGHT BY INCANDESCENCE.—In our Spanish contemporary, the *Crónica Científica*, M. Alf. Niaudet, after pointing out that the *Scientific American* agrees with him in his estimate of Mr. Edison's discoveries, proceeds to express a very decided conviction that carbon, and not platinum or any other metal, is the best material for the production of the electric light by means of incandescence. In support of this position, M. Niaudet adduces the following arguments:—1. At equal temperatures, carbon possesses a power of radiation in excess of that of platinum. 2. The heat capacity of platinum is far greater than that of carbon, and the former, consequently, requires a far greater amount of heat than the latter to bring it to a given temperature. 3. Carbon is a worse conductor of electricity than platinum, and, consequently, may be of greater diameter without the temperature being reduced. 4. Carbon is absolutely infusible, and may be brought to a white heat without the circuit being interrupted owing to fusion.

THE EFFECT OF ELECTRIFICATION UPON THE VOLUME OF BODIES.—At a recent meeting of the *Société Française de Physique*, M. Duter described an experiment which proves that, in certain cases, electrification produces an alteration of the volume of bodies. A large thermometer tube is converted into a Leyden jar by filling it with water which is brought into contact with a platinum electrode, and by coating its exterior surface with tin-foil. The moment this condenser is charged, the column of water is seen to fall; and it remains stationary so long as the charge remains accumulated, regaining its original level when the condenser is discharged. M. Duter varied the experiment in several ways; and was enabled to arrive at the conclusion that during the period of charge, the capacity and the exterior volume of the glass vessel became augmented; and, further, that this dilatation of the insulating sheath cannot be explained either by a rise of temperature or by electrical pressure.

PLATINUM COATING OF METALS.—A very interesting illustration of this method of coating metals with platinum discovered by M. Dodé, of Paris, was given by the inventor on Saturday at Messrs. Johnson and Matthey's Works, Hatton Garden. The process, according to the *Standard*, consists in fixing, by means of heat, a coating of the borate of lead and copper upon the metal to be treated, and then rubbing upon the glassy surface thus obtained a compound of platinum in oil of lavender, the platinum salt having previously been dissolved in ether. A further application of heat produces a beautiful silvery appearance, which, it is said, is not affected by oxidation. M. Dodé contends that this coating can be obtained at 1*d.* per square foot. The reducing action of many of the essential oils on the salts of gold, silver, and platinum have been for a long time past taken advantage of in coating with these metals. We remember some years ago seeing a mirror, in which a deposit of platinum was produced upon glass by the addition of oil of cloves to a solution of a platinum salt.

THE NEW LAMP OF M. DUCRETET.—A description of this lamp is given in our contemporary, *La Nature*, of Jan. 11:—"The particular principle which the lamp presents consists in the employment of a column of mercury in which one or more carbons are placed. The different densities of these substances causes the carbon to rise to the surface. To prevent this action and obtain the light, a carbon of somewhat larger section than the one immersed vertically in the mercury is placed horizontally, so that the end of the vertical carbon impinges against it. The light obtained is, therefore, similar to that of the Harrison, Regnier, or Werdermann light. A battery of from six to ten Bunsen elements has given good effects. One great advantage of this system is that the resistance of the circuit remains almost constant, that portion of the vertical carbon between the level of the mercury and the horizontal electrode forming what may be termed the real

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resistance of the circuit. It should be noticed, however, that the resistance is not absolutely constant, inasmuch as the carbon being consumed, the level of the mercury will be slightly lowered, and so the resistance is really increased by a constant quantity.

THE TELEGRAPH DEPARTMENT IN FRANCE.—According to the French journals, great administrative reforms are making headway in the Telegraph and Postal Departments. M. Cochery has devised a system of telegraph cards and telegraph letters for metropolitan circulation, which we can easily understand must be of great importance and convenience to all large mercantile cities, as well as a saving, ultimately, in the cost of delivery of telegrams. These cards and letters are to be transmitted to their destination by pneumatic tubes within half an hour of being posted. The telegraph cards will cost 5*d.*, and the telegraph letters, closed and sealed, 7½*d.* The system comes into operation on May 1st. It is clearly out of place to call these telegrams; we may suggest *pneumograms*, but, unfortunately, this involves an idea of a letter written or indicated by air or wind. Such a system has much to commend it, and we hope our own authorities will watch its progress and working. At the end of the financial year 1878 the receipts from the Post Office Department were 9,000,000 francs under the estimate. On the other hand, the telegraphs brought in 3,000,000 francs more than was anticipated, and this in spite of a reduced tariff.

THUNDERSTORM AT THE CAPE.—The Rev. J. Sharp, says the *Globe*, thus writes of a storm during which the Quaker Mission Church at Mouja (South Africa) was struck by lightning. The storm was so intense that the service had to be stopped. "Suddenly came a vivid flash and a tremendous peal, with smoke and dust; the window-frame was shivered from top to bottom. . . . L. Kitching was thrown from his seat to the floor. H. M. Dyke (missionary) was struck on the back of his head and shoulder; the hair of his wife was burnt, and her neck and chest scorched. Simultaneously Dr. Casalis sprang forward and lifted up his baby, a child 20 months old, who had been laid asleep on a seat close to its mother, but already the little lamp was extinguished. The babe was borne away; its mother remained seated in a semi-unconscious state, and unable to rise. . . . A considerable number were more or less affected; several women were speechless for hours. L. Kitching felt numbed, and circulation was not fully restored for three hours or more." A postscript written three days later says:—"L. Kitching is about well again. My head still feels the effect of the storm, although at the time I was not sensible of the flash which was seen to pass near where I sat." The moral of such a letter as this is that every building should be protected by lightning conductors. The expense would be trifling.

OBSERVATIONS ON THE MICROPHONE.—Dr. Bleekrode, in a letter to *Nature*, says:—"With regard to an explanation of the action of the microphone I observed a fact which, though it was already known from some anterior experiments with strong galvanic currents, has not been remarked, as far as I know, with this instrument. On connecting the current from six Grove cells with the microphone (the telephone not being in the circuit) composed of the three carbon rods, the vertical one assumes a vibratory motion between its supports, which causes a very audible sound, especially when placed on a sounding board. I think this experiment may serve as another illustration of the well-known fact, discovered by Ampère, of the repulsive action between the subsequent parts of a rectilinear current. Most of the experimental proofs bearing on this point leave some doubt as to a true demonstration, because a dilatation from the heating effect of the very strong currents used with metallic bodies may interfere, and are considered, for example, to explain the experiments of Forbes and Gore. But in my case, with a substance which has a very small coefficient of dilatation, I think the vibratory motion may be considered as an electrodynamic effect. As a supporting demonstration, I suspended with insulated metallic wires near another, three horizontal pieces of carbon (3 cm. long) in such a way that they could move freely away, and the two outer ones were connected with a battery of twenty Grove cells; *immediately* on closing the circuit a repulsion ensued between them and an oscillating motion set in, whilst bright sparks appeared between the contacts. This experiment may throw some light on a recent controversy which has arisen between Mr. Varley and Prof. Hughes. The latter insists on a change in contact resulting from alternating varying forms of the molecules or their spheres of action, in accordance with the sonorous vibrations. Mr. Varley points out a quite distinct cause. By using a contact-breaker moved with the hand he discovered, on applying a microscope with a 350 times magnifying power, when the circuit was closed or opened, a grey cloud issuing between the nearest carbon-points. This seems to prove that little particles of carbon are loosened by an effect of trituration on the contact-surface, the cohesion being lessened by the heating effect of the current. This cloud of microscopic dust serves as a vehicle to the current (when the carbon piece is vibrating), and its resistance, of course, is easily modified by the impinging sound-vibrations. Now, my experiment, though with a strong current, supports this fact, and shows that the vertical carbon is actually vibrating under its influence, and may prepare the above-mentioned condition, or at least render it very ready to change its contact in accordance with sound-waves acting on it with more or less force. Perhaps it will be observed that a microphone acts very well in transmitting sound when even the weak current from a couple of Leclanché cells is used, but then, also, we may admit a propensity (through the influence of this current) of the vertical carbon rod to get into a vibratory condition, which the sonorous vibrations will easily actuate according to their own period, if really it is not already vibrating at microscopical distances. Professor Hughes alludes to an experiment which, as he thinks, gives an evident support to his theory. In a sealed glass tube are enclosed five loose pieces of carbon with terminals to admit a current. He remarks that, properly pressed, mere mechanical shaking produces no variation of the current except that due to a constantly increasing resistance caused by abrasion of the carbon contacts, whilst under the influence of sonorous vibrations a varying current is produced, because the tube in this case is varying its length, and the molecules undergo proportional change of form. I think this proof may be as well, and with more probability explained by the facts mentioned above. The tube contains four or five *loose* pieces of carbon, and besides these, some air, which, as it is in a closed space, will press from all sides on the carbon parcels when it is put in vibration by sound, and therefore alter in a mechanical way their distances, the more because the surfaces in contact are rough ones. In conclusion, I will observe that the audible vibration of the vertical carbon rod in the microphone certainly elucidates the facts discovered by Blyth concerning sound transmitted only with coal cinders forming a receiving and a transmitting apparatus in a galvanic circuit."

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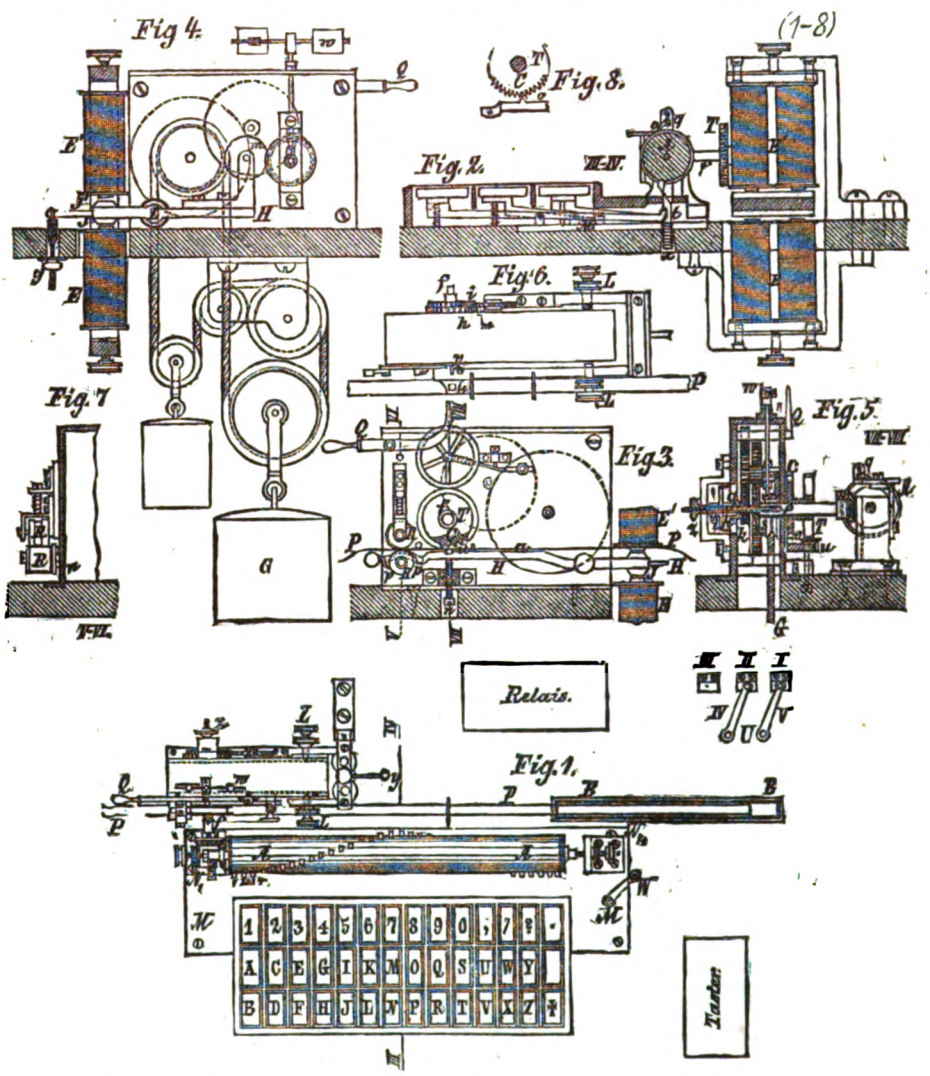
F. SCHWÄRZLER'S TYPE PRINTER.

We translate the following account of this instrument in its improved form from Dingler's *Polytechnical Journal*:—

"Of our illustrations, Fig. 1 represents a complete ground plan of the apparatus as perfected, while all the rest (Figs. 2 to 8) give various sections and parts of the same. The key board of the transmitter (Fig. 1) contains 42 keys, disposed in three rows, and the type wheel F 42 corresponding tables. By means of the white keys in the middle row are produced the intervals between the words, and the key maked + in the lower row serves for the stops, both corresponding cells in the type wheel being empty—that is, unprovided with types. As shown by segment III.-IV. of Fig. 2, taken from Fig. 1, each key, when pressed, acts with the end of its metal lever on a metal pencil *t*, raising it to such a height that it is brought within reach of the corresponding 1, 2, 3 . . . . of the 42 metal pencils in cylinder A. This cylinder is set in uniform motion through the wheel-work driven by a weight, G, by means of the axle *f*, and a pair of bevelled wheels. When one of its pencils comes in contact with a raised pencil *t*, it stops the current, but thereupon it immediately thrusts the pencil *t* along with it, so that this pencil becomes detached from its key, and, at the interruption of the current, is again drawn down by the spiral spring *x*. But the + key so far differs from all the others that its pencil is permanently fixed to the key lever. Then, in order to prevent the cylinder A from recoiling at the shock of the corresponding pencil in the cylinder against this immovable pencil *t*, another pencil, *o*, is attached to A, and another contact cone, *q*, to the stand frame (Figs. 2 and 5), by which contrivance a sufficient contact is produced at the reaction of the contact cone *q* behind the pencil *o*. The axles of the keys, together with the pencils *t*, are disposed on a metal plate, M, to which are at the same time adjusted the supports N_1 and N_2, of the cylinder A. These, however, are insulated.

"The wheel-work contains three wheels, and for a regulator has a fan *w* (Figs. 1 and 4), which is set in motion by a centing wheel *k* (Fig. 5), loosely adjusted to the axle *f*, with its trundle head *g*. There are, further, firmly attached to the axle *f* the type wheel T and the correcting wheel C. To the trundle-gear *g* of the crown wheel *k* is moreover firmly adjusted another wheel, *h*, with 60 teeth. By means of a spiral spring, *s*, winding round *f*, and resting against *k*, this wheel is pressed into the somewhat smaller wheel *i*, which is also provided with 60 teeth, while the friction of the two wheels, *i* and *h*, occasioned by the spring *s*, is regulated by the screw *s*. At the same time, a third wheel, *m* (Figs. 4 and 6), also provided with 60 teeth, plays into *i* and *h*, and is itself lodged on the anchor lever H of the two electro-magnets E and E′, while the two iron plates J and J′ serve as anchors. Then, as long as J′ is attracted by E′, *m* plays simultaneously into *i* and *h*, and transmits the motion (proceeding from G) from *g* and *h* to *i*, to the axle *f*, together with the type wheel and correcting wheel, and to the cylinder A. But when the plate J attracts E, *m* ceases to work into *i*; still, with the further action of the wheel-work, there arises a certain friction between *h* and *i*, the consequence of which is that the wheel-work, which has not now to drive along *f* and A, continues its motion uniformly.



"On the broad anchor lever H, revolving round the axle L, is fixed at *u* (Figs. 3, 5, and 6) the printing block, that is, a piece of wood covered with leather, and behind it the correcting tooth *v* (Figs. 5, 6, and 8), which plays into the teeth of the correcting wheel C when E attracts the anchor J. Lastly, on a prolongation of the lever H are further adjusted two stays, *p*, which act on a ratchet-wheel on the axle of the lower of the two cylinders R (Figs. 3 and 7), which provide for the shifting of the paper. The tape P comes, not from a roller, but out of a long narrow box B over little guiding pulleys. The balancing of the lever H and the regulating of the action of the electro-magnets E and E′ are effected by means of the detent-spring *y*, while the recoil of the anchor-lever is limited by an adjusting screw, *n* (Fig. 3).

"In the electro-magnets E and E′ it is not the line currents, but the current of a local battery that is brought into play. The line currents merely pass through a relay (Fig. 1), whose anchor-lever

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stops the local current in its resting position by E′, in its working position by E.

"The insertion is not quite the same in the terminal and intermediate stations, and is brought about at all the stations by uniform wire connections in the instruments by means of a contrivance U (Fig. 1) with two cranks IV. and V. and three contact plates I., II., III. At all the stations the negative pole of the line battery is connected with the resting contact of the key (Fig. 1), and the key axle by the relay right through with V. but the zinc pole with IV. At the terminal stations the plates II. are conducted to earth in the transmitting station V. standing on I., IV. on II.; in the receiving station, V. on II., IV. on III.; lastly, in the intermediate, V. on I., IV. on III. The line of telegraph runs from plate I. of the transmitting end to III. of the intermediate station, and thence from I. to III. at the receiving end. The batteries are thus closed while no despatch is being sent. Each station has, further, a rubber and a crank, W (Fig. 1), which, at the stoppage of the cylinder A on N_2, effects a metallic connection between cylinder A and plate M, and must do so as long as no telegram is being sent. On the other hand, the signalling station brings W to the place indicated in Fig. 1, and thus inserts its cylinder A and plate M, together with the pencils *t*, on the line. Thereby the negative pole at all the stations is brought to rest on the plate M and the key-board.

"In accordance with the foregoing, the process of telegraphing is as follows:—If a given station, A, wishes to speak, it first of all signals the desired station, B, by means of its key, whereat the anchor lever H of all the stations acts exactly like the Morse writing lever. When the signalled station replies, the work on the type printers begins; meantime the signalling station A has opened its rubber W, while the other stations keep theirs closed. Then station A sets the wheel-work of its type printer in motion by moving the arresting lever Q of its wheel-work with the handle directed upwards, thereby releasing the fly-wheel *w*. At the same time station A stops, that is to say, it touches the key +. When the pencil of the cylinder A effects a contact with the pencil of the key + all the relays cause the electro-magnet E to attract the anchor J, and the receiving station B perceiving this, and hearing the accompanying sound of the correcting tooth catching in the correcting wheel, forthwith sets its wheel-work also in motion.

"But both wheel-works at stations A and B have not yet driven the axles *f* and the cylinder A is now brought to a stop on +. As soon, however, as A releases the key +, thus interrupting the line current, the cylinders A and the type wheels in A and B attached to *f* begin to work synchronously. Now, also, A begins to telegraph, when, according to circumstances, as many as ten letters in alphabetical order may be simultaneously touched. But the cylinder A must never make more than *one* revolution without one key at least being touched; otherwise the synchronism would be endangered by the omission of the correcting action. Nor should it be forgotten that, strictly speaking, the maintenance of the synchronism requires a perfectly simultaneous working of both relays, as well as of the electro-magnets E and E′ at both stations. The rapidity of the cylinder A must be determined by the efficiency of the electro-magnets, and is regulated by a break in accordance therewith.

"When the key + is released and another key pressed, the cylinder A and type-wheel T at both stations begin to revolve, and the synchronous motion lasts until the corresponding pencil of cylinder A touches the pencil of the key still being pressed, transmitting the line current through the relays of both stations. Thereupon both relays interrupt the current in E′ and stop it through E, the anchor H becomes attracted at each station by the electro-magnet, and the wheel *m* raised out of wheel *i*; the break-spring begins to exert its regulating control on the wheel-work, the correcting cam *v* becomes pressed into the correcting wheel D, the tape is advanced to the right through the catch *p*, half the breadth of a type is pressed on to the arrested types by the printing block, and forthwith printed off. But, thereupon, the cylinder pencil at station A, hitherto effecting contact, immediately thrusts aside the pencil *t* of the key being pressed, thereby again interrupting the line current. The relays now send the local current again through E′, the tooth *v* is raised out of C, the wheel *m* again couples *h* and *i*, the break-spring once more ceases to act, and the catch *p* on the left again advances the printed tape half the width of a type.

"With this type printer the printing is effected exactly as with the Hughes, so to say 'on the wing,' that is, in such a way that the type wheel T and the cylinder A never really come to a stop. The emissions of currents are, in fact, so short that at each the correcting tooth remains for an extremely brief interval only in the correcting wheel, and the cylinder A, before coming to a stop, again interrupts the line current by thrusting aside the pencil *t*.

"Amongst the advantages possessed by this instrument over the Hughes we may mention the following. It is much simpler, and consequently may be fitted up at less expense, while far less liable to get out of order; it works quicker, because types following each other uninterruptedly may be printed off by the same revolution of the type-wheel; its insertion corresponds to that of the Morse; hence it works with the same sensitiveness as the Morse; and, lastly, has been shown by the test of experience to be practical."

ON A NEW FORM OF ELECTRIC LAMP.

BY THOMAS T. P. BRUCE WARREN.

Some time ago I devised the following method of conveying electricity to the different parts of a building for illuminating, and, as I see that M. Ducretet has recently brought the same idea for supporting the carbons before the French Academy of Sciences. I send herewith a full description of my method, which has given tolerably good results when tried on a small scale, and most efficiently acts in its extinguishing and relighting arrangements.

Ebonite or gutta percha tubes are laid in the same way as gas pipes in a house, and at suitable places are inserted ebonite taps, which communicate with a reservoir of mercury, on which floats the carbon pencil; the upper carbon is merely suspended by a good conducting substance to the "earth," &c. The system of tubes is connected with a small tank of mercury at the top of the building, which fills the tubes, and acts as conductor and regulator at the same time. When the taps are open, the mercury completes the circuit, the taps when shut simply breaking the column of mercury.

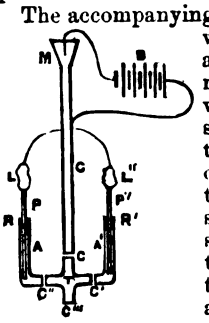
On an experimental scale glass tubing and a few T pieces connected with vulcanised rubber tubing answer perfectly; a few pinch cocks, as used for burettes, &c., will serve the purposes of taps.

If a tank of mercury is used for each floor of a building, the tanks themselves, which may be of iron, insulated from the walls, may be all connected together with stout copper conductors, so that one generator supplies the electricity for all the carbons.

It is better to have a metal tap to regulate the pressure, and an ebonite tap for extinguishing and relighting, so as not to interfere with the resistance of the circuits. An india rubber washer is placed on the carbon, through which it slips easily, whilst it prevents the mercury from flowing over. The flotation of the carbon, and the cohesion of the mercury will enable the friction through the washer to be so adjusted that no inconvenience will arise from a column of mercury the height of any ordinary room.

For the convenience of replacing the carbons, a 4-way piece, fitted with a pinch cock at its lower end, so as to empty the branches carrying the carbon, may be used instead of the T piece.

The accompanying diagram illustrates the arrangement which was used as a double-light chandelier. M is a small tank containing a few ounces of mercury (a small glass funnel will do as well as anything); G is a glass tube of small bore, connected with the funnel M and the 4-way piece T by means of small pieces of rubber tubing. This is more convenient than welding the parts together by heat, since it allows the use of pinch cocks instead of taps. The distance of the ends of the glass from each other in the rubber tubing should be only sufficient, so as to allow the closing of the tubes.



As C C′ C″ C‴ are ordinary Mohr's clips, by closing the lower end of T and filling M with mercury, the tube G and arms A A′ are filled with mercury. The clip C being closed and that at C‴ being opened, the mercury in A A′ may be drawn out for putting in fresh carbons, &c.

A wire from a battery, B, dips into the mercury in the funnel M, whilst the other wire from the battery is carried to two pieces of carbon L L″, lightly suspended over the pencils P P′. The pencils pass through rubber washers R R′, with slight friction only in the top of the arms A A′.

The arms A A′ may be made by simply bending two short pieces of tubing and contracting them slightly at the top.

The whole may be readily extemporised by using Hoffman's voltameter, or, preferably, a modification of this, which is supplied with an opening at C″. Of course, the stop cocks would be removed.

This lamp arrangement can be fitted up very efficiently for experiment at the cost of a few pence.

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THE ROYAL INSTITUTION AND THE ELECTRIC LIGHT.

Professor Tyndall, on the evening of Friday, the 17th January, and again on the evening of Monday, the 20th January, delivered at the Royal Institution a popular lecture on the electric light. The second lecture was delivered because of the large number unable to gain admission on the previous evening. On the 17th the theatre was, in fact, crowded, and three-quarters of an hour before the time of the lecture it was impossible to gain a footing inside the doors. This is another signal proof not only that Professor Tyndall is one of the very best lecturers; but also that his subject was one of great interest. No doubt a few who gained admission were somewhat disappointed to find the lecture popular and dealing with the historical more than the experimental. They expected to hear Professor Tyndall lucidly demonstrate some startling discovery made in the laboratory, instead of which he appealed to a wider audience, and, assuming that his hearers were not scientific specialists, he graphically detailed the results of this century's works, and sent them home at the end wiser than they were at the beginning of the evening. Professor Tyndall said the subject was suggested to him by the late honorary secretary (Mr. Spottiswoode), by whose side he had worked for thirteen years. His regret at the loss of such a companion had its opposite feeling in the pleasure with which he had seen him rising through sheer intrinsic merit, moral and intellectual, to the very highest post (the Presidency of the Royal Society) which it was in the power of English science to bestow. Professor Tyndall next thanked the gentlemen, inventors and others, who had assisted him in the collection of the information about the various arrangements for electric lighting now before the public, and those which for a while held a prominent position, but have at length been superseded. The electric light has been known for seventy years, as in 1808, and again in an improved form in 1810, it was shown to audiences at the Royal Institution. Sir H. Davy's carbon points "threw sunshine into the shade," and in 1808, 2,000 pairs of plates obtained for the Institution by subscription among the members produced such heat from the current they gave that quartz and calcium were melted as wax. It was early known that to produce heat and light in a circuit there must be resistance. This was illustrated by a wire composed alternately of platinum, which resists, and of non-resisting silver, when on the passage of a current the platinum became dazzlingly white hot. A non-resisting copper wire will carry enough electricity to split a resisting oak tree. In the case of two carbon points this resistance causes the one point to waste with double the rapidity of the other. This, which was formerly regarded as one of the two great obstacles to the general introduction of the electric light, had been overcome by various appliances of clockwork, which kept the two points at the proper distances apart. The second great obstacle was a more serious one, depending on an inexorable law of nature which demands an expenditure of force of one kind for the production of another. Zinc may be burnt in air—that is, oxidised; it may be also "burnt" or oxidised in acidulated water, but it has to displace the oxygen from the hydrogen for this to occur, and four-fifths of the heat produced are used up in this process. So that when zinc is thus "burnt" only the remaining one-fifth is available. The rate of "burning" makes no difference; one ounce of zinc, for example, always gives out the same amount of heat. This "burning" of zinc, which had been used in the production of electricity, was an expensive fuel, and this seemed to be a very great drawback to the general use of the electric light. In the year 1831 a discovery was made at the Royal Institution by Faraday—that of magneto-electricity. He showed that when the earth's lines of magnetic force are cut an electric current is produced. Professor Tyndall quoted Faraday's saying that he would rather occupy himself with finding fresh effects than spend his time in exalting those effects. But it was the exaltation of those effects which he first studied in a simple way which has led to the present possibilities of our electric lighting. In 1854 Werner Siemens, of Berlin, invented what is now known as a Siemens armature. The work of Mr. Wilde, of Holmes, the Alliance Company, Gramme, Siemens, Wheatstone, and Meritens was briefly described. We believe it is the intention of Professor Tyndall to publish his lecture in full in a well-known monthly, hence we shall not enter fully into the details. Mr. Wilde's work was highly praised, as was that of Holmes. The latter, said the learned professor, has been for some time under a cloud, his work has not been really understood, and the praise due to him has therefore not been duly awarded. It is to Holmes, however, that the first machines for the introduction of the electric light were due. Professor Tyndall, in speaking of the work of Dr. Siemens and Professor Wheatstone, stated that the making public a discovery either through the medium of some learned society or by means of the Press was the only way in which priority could be established, no other way could or should be recognised. The improvements of M. de Meritens were described as calculated to put inventors on their mettle. During the lecture a variety of lamps were lighted, most of which have been described in these pages.

In conclusion, Professor Tyndall said he would not then go into the questions of the division of the electric current and incandescence. All the laws of the subject he had been dealing with were known, and there was no room for a discovery in the scientific sense, but there was room for the application of such mechanical ingenuity as had given us the sewing machine, the phonograph, and many other things. The investigator and discoverer pursued his theme for the sake of gaining knowledge; the inventor's aim was generally to make money, though he gladly recognised that in many cases the inventor was stimulated by love of his art. Sometimes these men spoke disrespectfully of each other, as Cuvier despised the man of practical application, probably not taking into account that the application of science reacted on science. The amelioration of the condition of the community was, at any rate, an object worth labouring for. Still, it was well to remember that those discoveries and applications which struck the public mind and excited so much discussion, often come from men whose sole stimulus was an intellectual one. As to the philosophic aspect of the question, there was a small cohort of social regenerators, men of high aims, and for whom he had great respect, who would hand over science and scientific men to a hierarchy which would determine the particular subjects that the scientific man ought to pursue. Where that hierarchy was to get its wisdom, they never explained. Those writers denounced and scorned all reference to what they considered to lie far apart from human needs, and yet upon sensible conceptions—as of molecules, for instance—sometimes depended the greatest discoveries. When the feeble magneto-electric spark was first introduced, an Oxford don expressed his great regret that such a discovery should have been made, for, he said, it put a new and facile instrument in the hands of the incendiary. Let them imagine that hierarchy of which he had spoken watching Faraday peddling over his magnets. They would certainly have sent him back to the bookbinder's bench as a far more dignified occupation. Yet it was Faraday's spark that now shone, and which he hoped would illuminate our quays and halls, and esplanades and squares, and possibly also our homes.

LITERATURE.

A History of the Growth of the Steam-Engine. By Professor R. H. Thurston. C. Kegan Paul and Co.

This is the most recent addition to "The International Scientific Series," and is well worthy of a place in such a series. The author is almost as well known here as in his own country, and it is not too much to say that whatever is written by him is deserving of careful study. The history of the steam-engine is a history appealing to us all. It is part of a wider history, and one most intimately connected with it; that is to say, the history of manufacturing industry. This volume, then, should be appreciated, if only for the subject it treats, but its value is enhanced by the way in which the subject is treated. To enter into details is far from our purpose, as our space is too limited, but we may say that the author treats his subject in eight chapters, commencing with "The Period of Speculation, from Hero to Worcester," and concluding with "The Philosophy of the Steam Engine and its Application." After having read the portion specially devoted to history, which will be found amply illustrated, the student should not only read but carefully dissect all that is said in the concluding chapter. The author has endeavoured, and we think has succeeded, in tabulating the requirements and indicating the directions in which improvements are to be made. Let us quote two short paragraphs to show how fully the writer realises our present position. The general problem is "To construct a machine which shall in the most perfect manner possible convert the kinetic energy of heat into mechanical power, the heat being derived from the combustion of fuel, and steam being the receiver and conveyer of that heat" (pp. 466, &c.). . . . "Steam must enter the machine at the highest possible temperature, must be protected from waste, and must retain, at the moment before exhaust, the least possible amount of heat. He whose inventive genius or mechanical skill contributes to effect either the use of higher pressure steam with safety and without waste, or the reduction of the temperature of discharge, confers a boon upon mankind" (p. 471). These remarks are general, but the author also considers details, and the study of this volume will amply repay the time expended upon it.

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THE ELECTRICIAN.

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THE SOCIETY OF TELEGRAPH ENGINEERS, AND THE FORTHCOMING INTERNATIONAL TELEGRAPH CONFERENCE.

The untoward political events which led to the postponement of the usual Telegraph Conference last year, will not be wholly regrettable if the forthcoming meeting is rendered more interesting and serviceable by the delay. One of the several great Capitals of the Continent, in annual rotation, has been the place of assembly hitherto; but this year the high contracting parties of the Telegraph Convention will send their representatives to London. Formally speaking, London is only taking its turn; but the event cannot fail to awaken feelings and interests in this country which the mere official proceedings of the gathering would not have aroused; and the aspirations of those who desire to make the occasion noteworthy and memorable have our heartiest sympathy.

It is expected that the ordinary business of the meeting will be of somewhat unusual importance; and, taking place in London, the number of delegates from non-adhering administrations attracted to, it will, in all likelihood, be exceptionally large. That there will be no deficiency in hospitality we may be sure of in any circumstances; but from a country which may rightfully claim to be, commercially speaking, not only the originator but the chief promoter and guardian of Electric Telegraphy, something more than a kindly reception is to be expected. It was England who first proved the Telegraph to be a thing of practical and national utility; and it was from these shores that the electric wires were laid which first connected nations separated by the seas. Our ingenuity contrived the apparatus upon which, with rare exceptions, all signalling appliances have ever since been modelled; our manufacturers have supplied the material for telegraphic extensions all over the world; and our coffers have largely contributed the funds to carry them out. England, in short, is essentially the country of the telegraph engineer, and the country which enjoys to this day almost a monopoly of telegraph enterprise. If this had been the first of the Telegraph Conferences there would therefore have been a peculiar appropriateness in selecting our metropolis for the distinction. Coming as it does after several similar gatherings elsewhere, it is none the less right and proper we should make the most of it.

It was, perhaps, with some such feelings as these that the Society of Telegraph Engineers promptly and warmly took up last year the question of giving the Conference a suitable reception; and a considerable sum of money was, we believe, speedily forthcoming from members and others for that purpose. A *conversazione* on an unusual scale was projected; but the postponement until this year has given time to mature, and, it may be hoped, to enlarge the original conception. It is now rumoured that a scheme is on foot for getting up an Exhibition of Telegraphic Appliances. If this is to be done, no organisation could be better adapted to the purpose than that of the Society we have just named. We are not in its confidence, and we cannot speak exactly as to what is contemplated or what progress has already been made. We hope to return to the subject in due course when further information comes to light; but it may be useful, even now, to indicate what an exhibition of that kind might be, what it possibly may be, and what, under any circumstances, it ought not to be.

It is always difficult, and sometimes impossible, to achieve a great success; but it is generally easy to avoid absolute failure. We will deal therefore with the element of danger first. We had a conspicuous example of a worthless exhibition of the kind at South Kensington not so very long ago. The lesson it taught us will, it is to be hoped, not be thrown away. An Exhibition of the so-called "International" sort, like that at Paris recently, is not to be thought of either. It should be as free as possible from parochialism on the one hand, and from superfine inutilities on the other. We can afford to face comparisons, and we ought to boldly challenge them by inviting rivals from every available quarter. This brings us to an affirmative conception of what the Exhibition ought to be. It may be deficient in many things, it may be meagre as a whole, it may even be badly arranged, and yet escape actual failure; but, so far as it may attempt to go, it ought to be thoroughly catholic. That every representative, every Government, and every company ought to be invited to contribute items of their own choice no one will doubt; and we trust that the Society's agents abroad, and the Government of this and other countries, will be moved to assist in that way an undertaking which, though local in its origin,

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cannot fail to be instructive and valuable to all alike. We hope, at any rate, that our own Governmental authorities will be persuaded to afford liberal encouragement to the venture.

If the Society accomplish this much it will have done great things. But it is probable that national vanities, left to themselves, will give an exaggerated prominence to instruments which are the newest, most novel, and most elaborate. Our own notion is that it would be much more satisfactory to everybody if each country would let us see their workaday instruments of the humble sort as well. There is often more to be learnt from some local and obscure appliance than from many of its pretentious compeers. What it was originally intended for, what the operators have made of it, what it has given rise to, and what special uses it still subserves, are all questions of extreme interest to the practical man. England is exceptionally rich in the variety of these contrivances. Struggling against climatic difficulties which no other country has to contend with to a like extent, and being for a quarter of a century the field for unrestricted competition, she has a collection of signalling instruments which of themselves would form a curious exhibition—all of them useful in their way as supplying some special need or overcoming an exceptional difficulty. But other countries, too, have their lowly specialities, and it would be an odd thing indeed if there is nothing to be gained by seeing them. There may not be much profit in speculating whether the British signalman's weakness for the "double needle" finds its counterpart on, say, a Pomeranian railway; or the Irishman's passion for "sound" reading in the villages of Brittany; but if these "fancies" could anyhow be brought together something might be devised to find favour with all parties. As regards leading favourites, each country has its preferences. Sometimes national parentage determines the choice; sometimes the reason must be sought for in national idiosyncrasies. Nobody expects to materially disturb that state of things, but if it is attended by any serious inconvenience a thoroughly cosmopolitan exhibition of the kind we are advocating would tend to mitigate it.

And what is true of signalling apparatus applies equally to the material of construction. If it were possible to extend the scope of the Exhibition so as to include specimens of everything that is not common to all countries alike so much the better. Insulation, for example, is pushed in this country to the verge of pedantry. What we have to do, and how we do it, will open the eyes of a good many people; but what other countries are able to make shift with may also enlighten us a little.

Finally we may venture to hope that time will be afforded to compile a practically exhaustive description of everything exhibited; and from what we have already said it will be understood that by description in this connection we mean an account of the uses to which the article is usually put, rather than the details of its construction. The working value of a telegraph instrument is pretty generally in inverse proportion to its complexity. On the whole we feel satisfied that in the hands of the practical men who are on the Council of the Society of Telegraph Engineers for the ensuing year, there will be nothing flagrantly amiss with the arrangements whatever shape they may take. The few remarks we have ventured to make on this occasion are offered in a spirit of helpfulness and good will for the success of the movement.

ARE MORE ATLANTIC CABLES REQUIRED?

The subject discussed in the following letters is one interesting to a large number of our readers, and one we shall have occasion to refer to hereafter. Meanwhile, the following letters are worthy of careful attention, and we believe the proposed cable is not only wholly unnecessary, but that it is destined to meet with what its promoters merit—total failure. Our contemporary, *l'Electricité*, gives in its issue of the 20th January the circular, signed by M. Pouyer-Quertier, inviting subscriptions to the first issue of shares. The letters given below, we trust, will have the effect of compelling English capitalists to look closely into the affair, and we venture to affirm will assist them to decide that the facts do not warrant the speculation :—

(From the *Daily Telegraph* of Jan. 9.)

SIR : A few particulars of the scheme to lay two more cables across the Atlantic, to which you have called attention yesterday, may be interesting to the public. I have procured them as a shareholder in the Direct United States Telegraph Company. I was alarmed at the decline in my shares, but am now considerably reassured.

1. The present proposal to raise capital in Paris for an Atlantic telegraph is the second attempt of M. Pouyer-Quertier. This gentleman formed a company and had a public subscription opened towards the end of 1876. It was a failure, and no allotment was made. In the former case capital was asked for laying one cable; on the present occasion it is proposed to raise double the amount and lay two cables. M. Pouyer-Quertier apparently thinks that he failed because he did not ask for enough money. He is not an Irishman.

2. The total mileage of the proposed cables, according to the printed statement, is nearly 6,000 miles. This, at the price of 250*l.* a mile, which I have ascertained to be a liberal price for making and laying the best types of Atlantic cables, would represent a total of 1,500,000*l.* The capital of the new company is, however, to be no less than 52,000,000*f.* (2,080,000*l.*); so that there would be left for division—I suppose under the business term of profit—a sum of about 600,000*l.*

3. It is well known that there are four cables at work, that the Anglo cables have lately been "duplexed," and that these cables are equal to several times the amount of traffic. The 3*s.* tariff is not found excessive by the commercial public, who employ codes in which one word does duty for many, and the Press are satisfied, for they pay only 1*s.* a word for ordinary messages and 6*d.* a word for "deferred" messages. However, M. Pouyer-Quertier does not even hold out the bait of cheap telegraphy. His traffic estimates are based on the 3*s.* tariff and an assumption that the present companies will allow him without opposition to take away their traffic.

I need scarcely add that the French public are not informed of the history of the Direct United States Company. My shares, issued at 20*l.*, went, previous to the present working arrangement with the Anglo Company, to 6*l.*; they are now at 11*l.*, equal to 45 per cent. dis. If this is the value of a cable laid and working at a time when no hostile competition exists, what is the prospective value of M. Pouyer-Quertier's cable shares for which par is the price asked from the French public?

Perhaps you, or one of your correspondents, will be able to give an answer to this problem.—Your obedient servant,

SCRUTATOR.

(From *The Times* of Jan. 21.)

5, Great Winchester-street, E.C., Jan. 20.

SIR : You have recently called attention to the formation of "La Compagnie Française du Télégraphe de Paris à New York," which proposes to lay two cables between Europe and America at a cost of 2,000,000*l.*, which sum, it is said, has been guaranteed by three large credit companies in Paris. As the English investing public will no doubt be invited to subscribe to this undertaking, it might be well for the promoters to give some exact information on the following points :—

Why is the capital so large as 2,080,000*l.* when the total cost of two cables in working order need not exceed 1,500,000*l.* or or 1,600,000*l.*? What becomes of the other half million?

They propose to swing round the cable from St. Pierre to the United States coast. Have they obtained the consent of the holders of the existing Congress rights to do this?

Supposing the cable laid, have they made their arrangements for getting messages collected, distributed, and transmitted over any portion of the land lines of the United States? These are almost wholly in the hands of two or three corporations, who have already other interests to serve.

Their calculation of profits appears to be based on the existing tariff of 3*s.* per word, which leads one to suppose that a reduction in rates is not contemplated. Where, then, is the advantage of having another company? These are practical points. Should the information given be satisfactory, it will remove from the mind the impression that the project is framed with the view of frightening the Anglo-American Company into buying off the projected opposition.—Yours respectfully, ROBERT LORIMER.

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CORRESPONDENCE.

THE GOVERNMENT MONOPOLY AND INVENTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The subject of the Government Monopoly and Inventors with especial reference to the Telegraph Department is surely of sufficient importance if conducted in a spirit of "fair play" to demand something more than the fitful letters of such anonymous corrospondents as "J. L." and "Fair Play" who have each withdrawn after their first letter has been answered. "Fair Play" says he does not know what value I attach to "counsel's opinion" taken by my solicitors. I should have supposed that asking you to print that opinion sufficiently indicated my view of its importance. In order, however, that "Fair Play" may entertain no doubt as to the practical importance of that opinion, I may mention that it was immediately acted upon by my solicitors, who wrote to the Postmaster-General requesting him to take steps for appointing a meeting between the referees, which request and agreement were alike evaded by the following letters from the solicitor to the Post Office.

Upon that correspondence any comment of mine would be superfluous. Suffice it, therefore, to say, that the concluding letter addressed by my solicitors to the Post Office, and dated June 10, 1875, has produced no effect whatever, and that until the matter receives honourable consideration it must be self-evident that no man can wisely entrust that department with any original ideas.—Yours, &c., RICHARD HERRING.

27, St. Mary's-road, Canonbury, Jan. 20th, 1879.

General Post Office, 1st March, 1875.

RE HERRING.

DEAR SIRS: Your letter to the Postmaster-General of the 3rd ultimo has been laid before me, and I am requested to write to you in reply on his Lordship's behalf. Of the fact that your Client's Telegraph Instrument has had a full and fair trial at the hands of Sir William Thomson and Mr. Fleeming Jenkin, there can be no doubt; indeed the names of those eminent Electricians are, or ought to be, ample guarantee for this. It seems probable that your client's former advisers, Messrs. Vandercom, Law, and Co., were satisfied with what had been done. The circumstance that the trial resulted in the Postmaster-General's not authorizing the use of the Instrument for the purposes of this Department, ought not to be advanced as a ground of complaint on the part of your Client. The Post Office must be allowed to know its own business best. Your Client's invention may be one of great merit, but he could only look for the adoption of it here in the event of the Authorities, acting in the interests of the public service, finding it such in all respects as should justify their adopting it. I am therefore directed to inform you that the Postmaster-General is not prepared to comply with the request made to him in your letter.—I am, dear Sirs, yours faithfully, W. H. ASHURST, Solicitor.

Messrs. Makeson, Taylor, and Arnould, 59, Lincoln's Inn-fields, W.C.

59, Lincoln's Inn-fields, London, W.C., 17th March, 1875.

RE HERRING.

DEAR SIR: Referring to your letter to us of the 1st instant, we would observe that it is in no way an answer to ours addressed to the Postmaster-General of the 3rd February ultimo, and we are therefore compelled to ask you to reperuse that letter; and at the same time we repeat the request contained in it, namely, that steps may be taken by the proper officer for appointing a meeting between Professors Thomson and Jenkin, and Messrs. Clark, Forde, and Co., at any convenient time when Professors Thomson and Jenkin may be in London, in order that the further trial of Mr. Herring's Instrument may be proceeded with. We shall be glad of an early reply.—We are, yours truly,

MACKESON, TAYLOR, and ARNOULD.

W. H. Ashurst, Esq., Solicitor, General Post Office, St Martin's-le-Grand.

General Post Office, 22nd March, 1875.

RE HERRING.

DEAR SIRS: In reply to your further favour of the 17th instant, which was on its receipt laid before the Secretary, I am now directed to repeat the intimation conveyed to you in my former letter, that the Postmaster-General is not prepared to comply with your request. You must forgive me if I differ with you when you allege that my former letter was in no way an answer to your first communication.—Yours faithfully,

W. H. ASHURST, Solicitor.

Messrs. Mackeson, Taylor, and Arnould, 59, Lincoln's Inn-fields, W.C.

59, Lincoln's Inn-fields, London, W.C., 10th June, 1875.

RE HERRING.

DEAR SIR:—Your letters of the 1st and 22nd March caused us considerable surprise, and we can only suppose that when you wrote those letters you were imperfectly informed or forgetful as to the facts of this case. In order to prevent misapprehension, either by the Postmaster-General or any officer of the Department, or by any reader of our correspondence, we beg leave to offer the following remarks on your letters:—

We agree with you that the names of Sir William Thomson and Mr. Fleeming Jenkin ought to be an ample guarantee that Mr. Herring's Telegraph Instrument would have a full and fair trial at their hands; but the correspondence before us shows that the Instrument did not have such trial, and this has been admitted by Mr. Scudamore, on the Postmaster-General's behalf. The terms of reference to Sir William Thomson and Professor Jenkin were, on 17th June, 1872, agreed upon between Mr. Scudamore and Messrs. Vandercom, Law, Hardy, and Aston, solicitors for Mr. Herring. On 26th July, 1872, Professor Jenkin made a preliminary report addressed to both parties to the reference, which contains this passage:—

"It is very desirable that an automatic Wheatstone's sender should be arranged to send slips with actual messages, so that they may be recorded by Mr. Herring's Instrument. No trials can be quite satisfactory which do not exclude the imperfections of sending."

We find among the papers in this case the following minute:—

"Nov. 18, 1872. Write to Mr. Fleeming Jenkin with reference to his preliminary report on Mr. Herring's Telegraph Instrument, and request to be informed whether he is still of opinion that the Department should make, at its own cost, an automatic sender for the purpose of further testing Mr. Herring's Instrument. F. I. S."

We also find that Professor Jenkin wrote to Mr. Scudamore as follows:—

"In answer to your letter of the 18th, I beg leave to say that I think it unnecessary that an automatic sender should be made by the Department unless the officers of the Department think it desirable."

This letter of Professor Jenkin is manifestly inconsistent with the rules which govern the conduct of referees, and with the ordinary principles of justice, and it is necessarily fatal to the assumption of "a full and fair trial" which you would draw from the names of the referees. It comes to this, that one of the referees writes to one of the parties to the reference to inquire whether that party thinks it "desirable" that a step should be taken which the referee had previously declared "very desirable" for a satisfactory trial. In effect, the referee applies to one of the parties for directions as to the method of proceeding in the reference. A reference thus conducted would be an absurdity, and its result must be nugatory, and accordingly we find that Mr. Scudamore was sensible at the time that something more would be necessary to a satisfactory trial. On 19th December, 1872—

"Mr. Scudamore promised that if Mr. Herring wished a further trial of the instrument after Messrs. Thomson and Jenkin had made their report he would give his consent."

We have before us Mr. Herring's memorandum of his interview with Mr. Scudamore on that day, and Mr. Scudamore's letter of the next day, admitting that that memorandum "is accurate as far as it goes." When Mr. Scudamore thus promised "a further trial" he, of course, as well as Mr. Herring, had in mind his letter to Mr. Herring, of 5th October, 1871, in which he wrote:—

"In order to give you all reasonable satisfaction the department will be willing that that this final trial on a proper commercial circuit shall be carried on before one or more scientific persons acting on behalf of the department, but not connected with it, and one or more scientific persons to be chosen by you as arbitrators on your own behalf."

Sir William Thomson and Professor Jenkin made their report on 18th January, 1873. We find that on the 28th March, 1873, Mr. Herring wrote to his then solicitor, Mr. H. S. Law, a letter containing the following passage:—

"As Mr. Scudamore states in his letter that Sir William Thomson and Mr. Jenkin have already expressed their views to him, without waiting for the trial to take place, I presume he will not consider their opinion sufficiently free from bias to ask either of them to act on behalf of the department."

Mr. Scudamore, on the 3rd April, 1873, wrote to Messrs. Vandercom, Law, and Co., acknowledging the receipt of a copy of Mr. Herring's letter to Mr. Law, from which we have quoted, and stating that "Mr. Herring may if he thinks fit have the automatic sender put in hand at once." This, of course, was with a view to that further trial of Mr. Herring's Instrument, to which Mr. Scudamore had consented, and which, having regard to the correspondence already quoted between Mr. Scudamore and Professor Jenkin, it was not, as we submit, open to Mr. Scudamore to refuse. The letter concludes thus:—

"As regards the last part of Mr. Herring's letter, I beg that you will acquaint Mr. Herring that I adhere to the terms of the reference, but also to the referees, and that I will not hear of any other reference or any other referees at the cost of the Department."

Mr. Law, on the 15th May, 1873, wrote to Mr. Scudamore a letter recapitulating a verbal discussion which he had then recently had with Mr. Scudamore on "Mr. Herring's present position with the Post Office." This letter, which is of considerable length, concludes thus:—

"I ask you to reconsider Mr. Herring's request to associate two scientific men among those I have named to act on his part with Sir William Thomson and Mr. F. Jenkin, in the further experiments which you have agreed shall be made."

Mr. Scudamore, on 3rd September, 1873, wrote to Mr. Herring, as follows:—

"My remarks to you were to the effect that if I were satisfied that your Instrument possessed the advantages which you ascribe to it, I should willingly recommend its adoption; at the same time I distinctly gave you to understand that the satisfaction must come to me from the scientific advisers of the Department."

In order to show who were meant by "The Scientific Advisers of the Department," it may suffice to quote Mr. Scudamore's words used at the interview, to which we shall next refer:—

"I am acting upon the report of Sir William Thomson and Mr. Jenkin, and I do not see the good of referring this to Mr. Culley" (the Engineer in Chief of the Postal Telegraph Department).

On 15th October, 1873, an interview was held at the Post Office, between Mr. Scudamore and Mr. Herring, Mr. Law and Mr. Patey also being present. The notes of this interview, sent by Mr. Scudamore to Mr. Law, are before us. Mr. Scudamore begins the conversation by expressing his desire to come to a settlement as to the "really important questions" that are pending. He says:—

"The first (of these important questions) is as to what further trial there shall be of Mr. Herring's Instrument; that is certainly the most important. I consented on a former occasion that there should be another trial, and I am quite ready to act up to my promises made on that occasion. I said then that I would not incur any further expense on behalf of the Department by employing Professors Thomson and Jenkin again. I do not want to bring them to London on purpose to witness the trial or to take part in it. I have no doubt, however, that they will be in London again, and I shall have no objection to let them act on behalf of the Department then, if Mr. Herring is willing, and meet any gentlemen he is disposed to appoint on his own behalf."

Mr. Scudamore ends the conversation by saying:—

"We shall get for it (Mr. Herring's Instrument) any quantity of work it can possibly do, and if Professor Thomson or Professor Jenkin is in London Mr. Clark shall have the means of communicating with them, and he can say to them anything he likes and torture them in any way he

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pleases. I shall fairly take into consideration whatever report is made. I do not say offhand that I should agree with it, but it shall have fair consideration."

We invite you to consider what is the reasonable inference from all this discussion and correspondence, in which the parties to it must have meant something. Your letter admits that Mr. Herring was entitled to expect "a full and fair trial of his Instrument at the hands of Sir William Thomson and Mr. Fleeming Jenkin." The foregoing extracts show that Mr. Scudamore admitted that Mr. Herring was entitled, after Sir William Thomson and Professor Jenkin had made their report of 18th January, 1873, to a further trial, in the course of which those gentlemen should at some convenient time meet gentlemen appointed on Mr. Herring's behalf. This, then, is the "full and fair trial at the hands of Sir William Thomson and Professor Jenkin" which Mr. Herring asked, which Mr. Scudamore admitted his claim to, and invited him to make costly preparations for, and which you also by your letter allow that he is entitled to. Your suggestion that "our client's former advisers, Messrs. Vandercom, Law and Co., were satisfied with what had been done" would be sufficiently answered by the foregoing extracts from correspondence. We find, however, that on the 12th October, 1874, Messrs. Vandercom, Law, and Co. wrote to Mr. Herring a letter containing the following passage:—

"They (the Post Office authorities) are certainly wrong in this, that they did not carry out in its integrity the understanding we came to with Mr. Scudamore that your system should be fully and fairly tried by scientific men, two to be named by either side, and until this has been done we think you have just cause to complain."

We find, also, that Mr. Herring sent to you a copy of this letter, with a request that you would lay it before the Postmaster-General. We must express our astonishment that you should make a suggestion as to Messrs. Vandercom, Law, and Co., which the copy of their letter in your possession would have shown you was unfounded. But, as you appear unable to remember the purport of our client's communications to you, it is not surprising that you should misconceive his case. "The circumstance that the trial resulted in the Postmaster-General's not authorising the use of the instrument," was not advanced (as you assume) "as a ground of complaint" on the part of our client. Mr. Herring's complaint was, and is, that the Department promised that there should be a trial, invited him to prepare for it, proceeded with it to a certain point, and then refused to finish it. The Department promised, further, that if the trial were satisfactory the instrument should be adopted. It is enough, however, for our present purpose, to say, that Mr. Herring believes that "a full and fair trial" of his instrument would be advantageous to him. Such trial was promised to him, and he complains that this promise has been broken. As regards your claim that "the Post Office must be allowed to know its own business best," we may remark, that your letter shows that the Post Office knows one department of its business imperfectly. You say, that our client "could only look for the adoption of his invention" at the Post Office in the event of the authorities "acting in the interests of the public service, finding it such in all respects as should justify their adopting it." We must observe on this, that our client only looks for the fulfilment of that which has been promised to him. We contend that the authorities have not acted in this matter "in the interests of the public service," because those interests require full and fair performance of engagements. The Minutes of officers of the Department in reference to this matter sufficiently show in what spirit they have acted in it. We must observe, further, that in both your letters you have failed to meet the point of our letter to the Postmaster-General of the 3rd February. To prevent the possibility of mistake, we will repeat the request made by that letter to the Postmaster-General "to direct that steps may be taken by the proper officer for appointing a meeting between Professors Thomson and Jenkin and Messrs. Clark, Forde, and Co., at any convenient time, when Professors Thomson and Jenkin may be in London, in order that the further trial of Mr. Herring's instrument may be proceeded with." We had hoped that when you had carefully read the correspondence and other papers in this case, we might have received from you an answer which would at least attempt to deal with Mr. Herring's complaint. But as the policy of the Secretary appears to have been throughout the whole of the transaction one of evasion and subterfuge, and it would seem from your letter that he would wish you also to continue the same policy, and as Mr. Herring is not now in a position to adopt the legal remedy which he is advised is open to him, it only remains for him to print this correspondence, and to ask the public judgment on the proceedings of the Post Office in a "full and fair trial" of his invention.—We are, yours truly,

MACKESON, TAYLOR, and ARNOULD.

W. H. Ashurst, Esq., Solicitor, General Post Office, St. Martins-le-Grand.

[We think this correspondence might now be closed. Mr. Herring has given his views at considerable length, and we hold that any inventor who is not satisfied with the treatment received from a public department should be allowed to state his conclusions.—ED. E.]

THE ELECTRIC LIGHT.

(CONCLUDED FROM P. 108.)

Co-efficient of transmission.—If all the work $(W' - w')$ were transformed into *available* current in the external circuit, then $\frac{W' - w'}{W}$ = unity, where W is the total work performed by the observed current in a circuit of known resistance. In practice it will be found, however, that $\frac{W' - w'}{W} > 1$ (for many reasons). This expression, $\frac{W' - w'}{W}$, I have called the *co-efficient of transmission*, and designated it by the letter κ. κ is different for the different dynamo-electric machines which have been tried, and decreases with increase of current. Producing currents above 24 Webers, the following average values of κ have been obtained:—

Name of Dynamo-Electric Machine.	κ	Average Current in Webers.
C	1·01	31·0
A and B	1·12	31·1
D	1·28	27·9

Co-efficient of efficiency.—$\epsilon = \frac{w}{W' - w'}$; w is the useful work done in the circuit by the current. As the resistance of dynamo-electric machines and leading wires can not be made *nil* this co-efficient must be always smaller than unity. For currents above 24 Webers we have:—

Name of Dynamo-Electric Machine.	ϵ	Average Current.
A	0·62	29·5
B	0·53	31·0
C	0·47	32·6
D	0·30	27·9

Hence the dynamo-electric machine A converts 62 per cent. of the total energy transmitted into useful work, while 38 per cent. is lost in heating the machine. Dynamo-electric machine D converts 30 per cent. of the total energy transmitted into useful work, and loses 70 per cent. in heating its own wires.

Practical mechanical equivalent of the currents produced by dynamo-electric machines.—$\eta = \frac{W' - w'}{C}$, where C is the current in Webers. Above 24 Webers the different dynamo-electric machines produce the Weber at the following consumption of power:—Dynamo-electric machines A and B produce *one* Weber at 686·5 meg-ergs per second; dynamo-electric machine C produces *one* Weber at 736 meg-ergs per second; dynamo-electric machine D produces *one* Weber at 920 meg-ergs per second.—(N.B.—Through certain external resistances which are sufficiently small to get currents above 24 Webers.)

Regularity of the electric light.—If the resistance external to the dynamo-electric machine is represented by the resistance of the arc only, *i.e.*, resistance of leading wires equal *nil*, then although the light is naturally the most powerful, it is the least steady, since any variation of the resistance of the arc has then evidently the largest influence on the current and on the light. By connecting across the electro-magnet of an electric lamp another electro-magnet which acts as a shunt, and adjusting the two electro-magnets in such a manner that they produce *equal extra currents* when variations in the primary current take place, the regularity of the working of the lamp is greatly enhanced. An electro-static shunt will have a similar effect. For *strong lights* or *strong currents*, the electro-magnetic shunt is best; for *weak lights* or *weak currents* the electro-static shunt is best. The lamp should be constructed mechanically so well and delicately that the carbon points run together with a minimum tension of the spring of the lamp. Then the lamp will be a balance with small weights. When making photometric measurements, to get more trustworthy results, it is best to use a *flat carbon* (2 to 3mm. thick) as the positive electrode, and a carbon of the usual form as the negative electrode. The light is to be observed in a line normal to the flat surface of upper carbon, and passing through the centre of the arc. In this manner the largest quantity of *total light* produced is measured, and, moreover, the ratio between *total* and *external* light is more constant. The lower carbon should be invariably of less section than the upper carbon. Further, when producing the light by a short arc, which it is always advisable to do, the lower carbon should be *natural* carbon. Coppering the carbon is advisable under all circumstances. Artificial as well as natural carbons appear to be very little hygroscopic, a great fortune for damp climates like India during the monsoons. When the arc is long, the flame by combustion of the carbons is large. This appears to be due to the fact that for a long arc the vacuum formed round the carbon points by expansion of the air by heat is less complete than in an arc of shorter length. The consumption of the carbon points is due more to combustion than to disintegration. The incandescent part of the carbon points has so much more intensity of light than the flame that the latter causes a shadow. The hissing noise produced by the electric arc is, I believe, due to the formation of a vacuum round the incandescent carbon points. The

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noise is much stronger in a short than in a long arc. It may also be due in part to the disintegration of the carbon points. The noise of the electric light in a quiet room is simply unbearable. This speaks only *against* the use of the electric light for domestic purposes.

There can be no doubt that one length of arc is best under given circumstances, considering both the intensity and regularity of the light. The light permanently decreases with length of arc, hence the arc should be made as short as possible. This would, however, be bad for the constancy of the light, and may also spoil the dynamo-electric machine. Hence adjust the commutator by turning the brushes in the direction of the rotation until only small sparks are observed. If this is impossible make the arc longer by lessening the tension of the spring. In this manner the best length of arc can be experimentally found. This would give the best tension of the spring at the starting point. Now let the dynamo-electric machine run for several hours, and make the same experiments, when the best tension of the spring will be found somewhat less. Take the mean of the two tensions and fix the micrometer screw.

Proportionality of light and current.—Although the light produced in the arc must be very nearly proportional to the total energy consumed in the arc (minus the energy expended in giving the disintegrated carbon particles velocity), the resistance of the arc decreasing with increase of current, it follows that the light *cannot* be proportional to the square of the current. If we make the highly probable supposition that the resistance of an arc of constant length is inversely proportional to the current which passes through, then the light produced would be proportional to the current. This appears to be the case. The conduction of the arc appears to be due to two causes, rarefied air and carbon particles flying in both directions. Both causes would point towards an *inverse* proportionality between current and resistance of arc.

There are many other novel points of great interest to be discussed, and many more practical and scientific results, I have no doubt could be elucidated from my experiments, but unfortunately, I must conclude here, since I have to start for India in a few days. The completion of the results shall, however, be given in my final report which is in preparation.

London, Nov. 1, 1878. LOUIS SCHWENDLER.

PROFESSOR MOSES G. FARMER ON THE ELECTRIC LIGHT.

A correspondent of the *New York World* communicates to that paper the results of a recent interview with Professor Farmer. He first quotes from a letter written by Professor Farmer, and then proceeds to give some details of the interview. The following abstract will enable our readers to gain some idea of Professor Farmer's views upon the subject:—

"'Some few of the citizens of Salem (among them ex-Mayor Williams, Mr. George D. Phippen, Mr. J. H. Phippen, and perhaps others) will, doubtless, recollect a parlour at No. 11, Pearl-street, Salem, Mass., which was lighted every evening during the month of July, 1859, by the electric light, and this electric light was subdivided too! This was nineteen years ago, and it was, undoubtedly, the first private dwelling house ever lighted by electricity. A galvanic battery of some three dozen six-gallon jars was placed in the cellar of the house, and it furnished the electric current, which was conveyed by suitable conducting wires to the mantelpiece of the parlour, where were located two electric lamps on each end of the mantelpiece. (I would not wonder if the screw holes were there at this day.) Either lamp could be lighted at pleasure, or both at once, by simply turning a little button to the right for a light, to the left for a dark. No matches, no danger, no care to the household, nor to any one except to the man who attended to the battery. The light was noticed as being soft, mild, agreeable to the eye, and more delightful to read or sew by than any light ever seen before. Its use was discontinued at that time, for the simple reason that the acids and zinc consumed in the battery made the light cost about four times as much as an equivalent amount of gas light.'

"Professor Farmer was requested to give his views—first, upon the gas company scare; second, as to the merits of the electric light; third, regarding the mode of conducting it through the public streets; fourth, as to its cost; fifth, regarding the production of electricity.

"Speaking of the scare in the gas stock market, the Professor said he thought it was certainly premature, for at present there was not more than one hundred electric lights in practical use throughout the land, and, compared with the number required for the illumination of the country, they were as nothing. 'Suppose,' said he, 'you wanted to give light to the citizens of New York, each one requiring equal to a 10-foot gas burner. Reckoning on the basis of 1,000,000 people you would want 10,000,000 candle lights. If you wanted it divided up into small lights you could not expect to get more than 500 candles per horse power, and that would require at least 20,000 horse-power to light the city. In order to accomplish this there would have to be made machines, steam engines (to a large extent purposely for it), magneto-electric machines to furnish the electricity, and it would not be advisable to have them average more than 5,000 candles each for fear of getting out of repair. That would require 2,000 magneto-electric machines, which could not be produced in a moment. It would perhaps be desirable to have five electric lamps to each machine, and that would require at least 20,000 lamps.

"'While some of the manufacturers are prepared to supply in a certain time their particular style of lamp, yet the public has not decided which is the best to use. No lamp at present in use has such manifest superiority that every person will buy that particular one. None at present in use is properly adapted to minute and profitable subdivision of the electric light. This is an entirely different condition of things to gas illumination, in that factories already exist, and the means of supplying gas fixtures, tubing and piping. Gas pipes are already laid in the streets, which would be utterly worthless for the distribution of electricity for the purposes of the electric light, and while competent electrical engineers are sufficiently well acquainted, theoretically and practically, with the distribution of electricity for telegraphic purposes, yet a distinct branch of electrical engineering science needs to be inaugurated and carefully studied before any expensive system of electric distribution should be entered upon; and although I expect to see the electric light widely introduced, and that very soon, yet I do not conceive that it is going to supplant and displace, to a very large extent, the consumption of gas immediately. But it may and doubtless will have the effect to stimulate and hasten the use of gas for heating purposes as well as those for illumination, and so I expect the consumption of gas to increase rather than decrease after the effect of the scare is over. I venture the opinion that in five years from now there will be more gas consumed than there is to-day, proportionately also with the increase of the population. One of the effects of the introduction of the electric light for the purpose of illumination will be the stimulating inventors to produce apparatus for the consumption of gas for heating purposes.'

"Touching the merits of the electric light, Professor Farmer said it would eventually approximate the quality of daylight for the display of goods and merchandise in warehouses. It would be vastly superior to gas for the illumination of workshops and manufactories, for with the same expenditure a better and greater diffusion of light would be obtained. He considered a room fairly lighted that has one candlelight to 125 cubic feet of space, very well lighted with one candle to seventy-five cubic feet of space, but with the electric light properly distributed it would be easy to have one candlelight to each forty or fifty cubic feet of space, and this would be accounted a very brilliant illumination. The light, he thought, would render great service in the mining regions, lessen the expense, and diminish the dangers. It will render it perfectly feasible to carry on great enterprises by night as well as by day—such as tunnels, bridges, and constructive operations in general, and prove useful for billiard halls, which are lighted with difficulty by gas; and, if necessary, great agricultural operations could be carried on by night at profitable expense in harvest time. The lighting of streets and other public thoroughfares will be accomplished satisfactorily, and at much less expense than the present mode of lighting by gas; and so there would be more illumination for less money, and a good street lamp at night is preferable to a policeman.

"With reference to the mode of conducting electricity through the streets, the Professor said that copper wire was the cheapest conductor, and so will be universally used. The best mode of insulating wires underground for conducting electricity for electric illumination was as yet undeveloped, and will need careful investigation, because the frequent accidents to which subterranean wires are exposed will necessitate the having of a corps of electrical engineers for this special occupation or art, for while it is somewhat of the same character as conducting electricity for telegraphic purposes, still the conditions would be that of another department.

"Regarding the cost where power is already in use for manufacturing purposes and where there is an available surplus and it can be used for the production of the electric light, as at Fall River, Providence, Lowell, Manchester, Nashua, Cohoes (N.Y.), and multitudes of other places, the electric light can be furnished very much cheaper than gas is at present supplied, perhaps for from one quarter to a half the cost. There are two elements that enter into the cost of the electric light—the cost of the power consumed in producing it,

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which costs only when used, and the cost of interest on the plant, which is as great when not in use, for it, like a blister, draws all night long. So if the light is only to be used for an hour or two the cost of interest and depreciation might exceed the cost of the power consumed. For instance, the horse-power in some cases could be furnished at $70 per year, while the interest and depreciation on a 5,000 candle machine might cost as much more. So if the light is to be used but a small portion of the time, it would be relatively considerably more expensive than if required to be used all the time. The cotton manufactory would be at one extreme and the coal mine at the other.

"Of the production of electricity, Mr. Farmer said that it cannot be stored and the storehouse drawn on at pleasure. It must be produced as and when wanted. The electricity for the purpose of illumination is produced by the movement of coils of copper wire in the neighbourhood of magnets. Electricity is developed in condition whenever it is moved across the lines of force streaming from a magnet. The electricity is more powerful the more rapid this motion; more powerful the longer the wire, and more powerful the greater the intensity of magnetism in the magnet. These are the fundamental facts that underlie the construction of all magneto-electro machines. Any more technical description of the process of producing electricity would scarcely be understood by the general reader. In concluding the interview, Mr. Farmer said, 'While our gas stocks have depreciated, and may not, possibly, return to their former value, I do not look to see the companies cease to pay good, fat dividends.'"

SOCIETY OF TELEGRAPH ENGINEERS.

The first meeting this year of the above Society was held on Wednesday evening, the 22nd instant, in the hall of the Institute of Civil Engineers, Great George-street, Westminster, when the inaugural address was delivered by Major Bateman-Champain.

Dr. C. W. SIEMENS (late President) occupied the chair, and after the transaction of some routine business, briefly introduced Major Champain as his successor. He was quite sure that the gentleman was sufficiently well known to them all, and that he was so well known to the telegraph world throughout, that he (Dr. Siemens) need not say anything in his favour. He then vacated the chair, which was at once filled by

Major BATEMAN-CHAMPAIN, who said it was not without considerable diffidence that he had ventured to accept the position of President of the Society, but he would later on give his reasons for this. He then observed that the annual report of the Council for the past year showed that the progress of the Society had continued steady, and had been satisfactory. They now numbered in their ranks over 1,000 members, associates, and students, and they might anticipate that every year would add to their strength. The science of which they were votaries was making such amazing strides and exciting such wide-spread interest that it was quite reasonable to anticipate that their numbers would go on increasing. The important question of finance had recently attracted considerable attention among them. The Society was now, in consequence of the assistance afforded by members, well established, but, comparatively speaking, it was in its infancy, and consequently they had no accumulation of funds by them, so it would be necessary for some time to pay special attention to economy. It was, however, satisfactory to know that the economies proposed by the Council would greatly reduce their annual expenses, and enable them to commence the year 1879 with an unclouded prospect. It was unnecessary for him to point out how innumerable were the subjects for their Society to deal with. The application of electricity to our every-day life was being spread with marvellous rapidity, and scarcely a day passed without producing fresh evidence of the work of the practical electrician. He then gave a retrospect of the main achievements of the year with regard to the science in which they were interested, confining himself, he premised, to broad facts, and avoiding, as far as possible, personal opinions. Among the most striking facts connected with electricity in the past year the subject of the electric light stood prominently forward. With respect to the lighting of streets by electricity, it was rather remarkable that the idea had been taken up more on the Continent than in England, and London had not been so prominent as regards this question as she used to be. The experiment, first tried on an extended scale in Paris, Madrid, and other cities, appeared to have set an example to London, and trials were now being made of various systems in Holborn, on the Thames Embankment, at the Mansion House, and other places. Mr. Schwendler had been carrying on laborious tests to discover the best plan of applying the light to the Indian railways; and for this purpose he advocated large lights, few in number, and he believed that the results would be preferable to the subdivision. Although the experiments now being conducted might not conclusively settle the question as to the value of electricity as a means of illumination, they could not fail to be useful and instructive, and they would undoubtedly lead to many improvements being made. The difficulties, such as the subdivision of the light, &c., at present in the way of its adoption where gas was now employed, had not yet, and might not be entirely overcome, but they knew that some of the most inventive and practical men of the age were concentrating their energies in the endeavour to solve these things. It was not impossible that, by a judicious employment of the electric light, our crowded river might be illuminated in such a manner as to enable the traffic on it to be conducted by night as well as by day, and its employment on ships would be very advantageous, and collisions might thus be avoided. It had been clearly shown by late experience how widely, especially over large areas, the light might be used. He then referred to and commented on Bell's telephone, the phonograph—as to which he said there had been many fruitless attempts at constructing speaking machines, while the phonograph was as remarkable for its complete reproduction of the human voice as for its simplicity—Hughes's microphone, the carbon telephone—which had rendered Edison's name so celebrated—the microtasimeter, and other inventions which had made the past year remarkable, and he also alluded to the collection of telegraphic apparatus exhibited at the Paris Exhibition last year. Turning to submarine enterprise, he said that the final abandonment of two of the Atlantic cables might be looked on, perhaps, as furnishing some information as to the life of that type of cable. They had been immersed for twelve years, and, in consequence of the decay of their outer covering, they became too weak to be lifted for repairs, and the attention of electricians might well be employed on the important subject of protecting the outside covering of submarine cables. The Eastern Telegraph Company had during the year laid about 620 miles in the Levant, besides 370 miles on the Cyprus extension, and the West India and Panama Company had laid a line from Cuba to Jamaica. He then referred to the cables under construction by the Telegraph Construction and Maintenance Company, and said, to show the amount of private enterprise in submarine telegraphic undertakings, that over twenty large steamers were constantly employed in different parts of the world in repairing and maintaining the many cables which were now lying in almost every sea. As to the improvements for increasing the speed of signalling, he alluded to the duplication of certain companies' cables. Although the improvement and perfection of the apparatus and machinery in use for the transmission of messages were, undoubtedly, objects of the first importance to them, yet he was of opinion that, as telegraphic engineers, they might now and then direct attention to the means by which that machinery was managed and controlled. This summer would, they hoped, witness in London the assembly of one of the international conferences held from time to time to revise and, where necessary, modify the legislation accepted by the adhering States. It had been his duty to attend one or two of these conferences, and he was acquainted with many of the foreign delegates, and so he thought he might render some small service to their Society as their president, and this is what had induced him to accept that position. He then gave some very interesting information relative to the various telegraphic conferences which have already been held, observing that it was not till nearly the middle of this century that the lines in one country crossed those in another, when international telegraphy became an established fact. The necessity of a society for making laws was immediately felt, and, from comparatively small beginnings, the present complete system had been drawn up. The International Convention did not lay down laws for the internal lines of a state, but international messages were all taxed, and generally treated in strict accordance with the Convention's laws. Since the date of the earliest meeting in Paris, 26 years ago, periodical assemblages had been held. The original one was attended by the representatives of Belgium, France, Prussia, Austria, Bavaria, Saxony, Hanover, Wurtemburg, and Holland. State after State then begun by degrees to join in the subsequent conferences, and at the last meeting at St. Petersburg, all the nations of Europe, besides some extra-European countries, were represented. From 1852 to 1858 these conferences were, comparatively speaking, rather numerous, partly because different arrangements were entered into between different administrations, and partly because such comparatively frequent meetings were felt to be necessary. After mentioning the dates and places of the chief conferences which had been held, he said the rule at present was to meet once in three years. A conference would, therefore, have assembled last year; but, from the disturbed condition of Europe and other causes, it was postponed till the summer of 1879. At the earlier conferences each State was represented by a diplomatic official

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of rank, but latterly the delegates had usually been officers of high standing in the different telegraphic controls, and they had power to agree to, and generally approve, alterations, subject to eventual ratification by their respective Governments. Although it was the custom for each State to send more than one official to the conference, a single vote only was given to each State. In 1868 the telegraphs of this country were not worked by the Government, and consequently the British Government was not represented at the conference at that date, but this country joined the conference after purchasing the land lines from the companies, and delegates were deputed to represent this country at the Conference at Rome in 1872, on which occasion one vote was given to England and one to India. With regard to the international tariffs, he gave a brief outline of what was agreed on at the early Convention in Paris, and afterwards sketched some of the principal modifications and the chief provisions made to keep pace with the times. Although a quarter of a century had elapsed since the first convention was drawn up between the representatives of the few States at Paris, its enactments, so far as they went, had virtually formed the groundwork of all the subsequent legislation—a fact bearing testimony to the completeness with which they were prepared. The main thing was the right of all persons to use the international lines on prepayment of their messages, the languages to be used being French, German, and English. No message could be sent in cipher, and the charge for any message lost, mutilated, or mislaid, should be refunded. The first order was Government messages, then service messages between telegraph administrations, and then messages from the public; and it was provided that a message stopped in consequence of interruption of the line should be forwarded by post, and that all international offices should be opened during specified hours. The unit of charge was for a standard message of 20 words, with double the rate at night, and each contracting State was divided into a number of zones, with separate charges for each zone, according to its distance from the frontier. He then referred to the alterations made from time to time as to the standard messages and tariffs, and spoke of their present position. The question of how far the telegraph rates could be cheapened, and thus cable means of communication placed within the reach of a larger class than at present, was one of the greatest interest. Mr. David Chadwick and other gentlemen thought that the time had arrived when the ocean telegraphs should be purchased by the Government, and as long ago as 1872 a paper giving expression to this view, together with arguments in support of it, was submitted by the Society of Arts. An elaborate and able essay on the subject of tariffs was written not long ago by M. Vinchent (representative of Belgium at the conference, and one of the most distinguished authorities). The same rule as to postal and telegraphic work did not apply, as telegrams must be manipulated one by one. The real labour of a letter was performed by the writer, while, in the case of the telegraph, all was done by the departmental officials. Roughly speaking, the carrying capacity of the post, by means of trains, vans, &c., was unlimited, while that of a wire was restricted to so many words a minute. He, however, ventured to foretell a steady and gradual reduction in tariffs and cheaper telegraphy. A remarkable paper on the "Law of International Telegraph Tariffs" was read before the Society in April last, and it deserved close and careful study. Attempts had been made to induce the various Governments to make the telegraphs neutral in time of war, and some of them had recognised the civilising tendency of the proposal, but no decisive step had yet been taken in the matter. The international offices must now be kept open throughout the 24 hours; all extra night charges had been done away with; a very large number of languages were now accepted as suitable for corresponding, it being stipulated that every message be written in Roman characters; and every one could now employ ciphers. The head quarters of the International Conference were at Berne, where were addressed all proposals for modifications of rules. The expense of maintaining this central office was borne by the contracting States, according to the importance of each administration. Before the members of the conference disperse they decide where the next assemblage shall take place. He was rather of opinion that the conferences met too frequently, and that once every five years would be sufficient. He then spoke of the courtesy with which the representatives had been treated in the various countries where they had met, and expressed a hope that those who were sent to the conference of 1879 might be given the same cordial reception which they had experienced elsewhere. He had no doubt that the Society of Telegraph Engineers would be well to the front.

Mr. GRAVES then moved, and Professor AYRTON seconded, a vote of thanks to the President, which was carried with enthusiasm.

On the motion of Mr. PHILLIPS, seconded by Mr. NEWMAN, a similar compliment was proposed to the late President, whose valuable services to the Society were warmly eulogised.

Dr. SIEMENS, in reply, expressed the very deep interest he had taken in the welfare of the Society, of which they had done him the honour twice of electing him President. The year now commencing would be a very important one for the society. The first telegraph conference in London would be held, and the Society must give the representatives a warm approval. He hoped that under their new President—who was, he said, in every way qualified for the position—their Society would continue to prosper.

THE EASTERN TELEGRAPH COMPANY (LIMITED).

Abstract of the report of the directors to be presented to the Thirteenth Ordinary General Meeting, 30th January, 1879:—"The directors submit the accounts and balance sheet for the six months ended 30th September, 1878. The Company's revenue for this period amounted to 207,347*l.* 19*s.* 6*d.*, from which is deducted 56,339*l.* 17*s.* 3*d.* for the ordinary expenses of the Company, and 20.154*l.* 3*s.* 3*d.* for special expenditure during the half year, as shown in the annexed accounts, which, with 2,726*l.* 2*s.* 6*d.* for income-tax, leaves the sum of 128,127*l.* 16*s.* 6*d.* net profit. From this amount, 32.269*l.* 13*s.* 2*d.*, the interest on debentures and the dividend on the Six per Cent. Preference Shares to 30th September, together with two interim dividends on the ordinary shares for the quarters ending 30th June and 30th September, 1878, amounting together to 92.425*l.*, have been paid, leaving a balance of 3,433*l.* 3*s.* 4*d.* to be carried forward. The several sections of the Company's cables remain in good working order, with the exception of the Lisbon cable, which is now under repair. The Company's cable repairing ships, stationed in the Mediterranean and the Red Sea, are in efficient condition, and in readiness for the Company's requirements. The Joint Purse Agreement between the Indo-European Telegraph Department of H.M. Indian Government, the Indo-European Telegraph Company, and this Company, continues to work satisfactorily. By the resolution of the Extraordinary General Meeting of Shareholders, held on 9th August last, the directors were empowered to acquire the shares and undertaking of the Black Sea Telegraph Company (Limited), and to raise capital for the purpose; and for the laying of a new cable between Alexandria and the Island of Cyprus. The transfer of the shares of the Black Sea Telegraph Company has been completed, and the cable (from Constantinople to Odessa) is now worked as part of this Company's system. In accordance with arrangements made with H.M. Government the Company has connected Cyprus with Alexandria by cable, and is now constructing land lines in the island. The capital required for the new works has been raised by an issue of Five per Cent. Debentures, payable 1st August, 1887, of which 181,900*l.* has been issued to the shareholders up to this date. Two of the directors, the Marquis of Tweeddale (Lord W. M. Hay, M.P.) and the Right Hon. W. N. Massey, M.P., retire by rotation, and being eligible, offer themselves for re-election."

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Jan. 22.		Business Done Week Ending Jan. 22. Highest.	Lowest.
Anglo-American	58,	¼	58¼	58¼
Do. "B"	84½	¼	84¾	84¼
Do. "A"	33,	¼	33¼	33¼
Brazilian	6¾,	¼	6 13-16	6¾
Cuba	8½,	9½	—	—
Do. Ten per Cent. Preference	15½,	¼	15⅝	—
Direct Spanish	1½,	2	—	—
Do. Ten per Cent. Preference	9½,	10½	—	—
Direct United States	11½,	¼	11½	11¼
Eastern ex div.	7½,	⅛	7⅛	7⅛
Do. Six per Cent. Debenture	104,	7	—	—
Do. Five per Cent. do.	102,	5	—	—
Do. Six per Cent. Preference ex div.	11½,	¼	11½	11¼
Eastern Extension ex div.	7½,	¼	7¼	7¼
Do. Six per Cent. Debenture	106,	8	107¼	—
German Union	8,	¼	—	—
Globe Telegraph and Trust	5,	¼	5¼	5
Do. Six per Cent. Preference	10½,	¼	10¾	10⅜
Great Northern	7½,	8½	8½	8
Indo-European	19,	20	—	—
Mediterranean Extension	2½,	3½	3	—
Do. Eight per Cent. Preference	9,	¼	—	—
Reuter's	10,	11	—	—
Submarine	217,	22	221	219
West India and Panama	1½,	2½	2	1 15-16
Do. Six per Cent. Preference	8½,	¼	8½	8 3-16
Western and Brazilian	2½,	¼	—	—
West. Union Seven per Cent. 1st Mort.	114,	18	—	—
Do. Six per Cent. Sterling	101,	3	—	—

TRAFFIC RECEIPTS FOR DECEMBER, 1878.

Companies.	Dec. 1878.	Dec. 1877.	Increase.	Decrease.
Anglo-American Telegraph Company	47,040	45,570	1,470	—
Brazilian Submarine Company	14,231	12,318	1,913	—
Cuba Submarine Company	2,800	2,666	134	—
Direct Spanish Telegraph Company	939	857	82	—
Direct United States Telegraph Company	13,970 estd.	12,930	1,040	—
Eastern Extension Telegraph Company	22,929	23,980	—	1,051
Eastern Telegraph Company	38,467	37,777	690	—
Great Northern Telegraph Company	14,803	—	—	—
Submarine Telegraph Company	8,498	8,754	—	256
Western and Brazilian Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	2,250	1,850	400	—
West India and Panama Telegraph Company	5,304 estd.	4,558	746	—

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NOTES.

THE DIRECT UNITED STATES CABLE COMPANY (LIMITED).—The directors have resolved upon the payment of an interim dividend of five shillings per share, being at the rate of 5 per cent. per annum for the quarter ending 31st December, 1878, such dividend to be payable on and after the 15th February next.

THE STRING TELEPHONE. — M. Niaudet attributes the invention of the string telephone to M. Weinhold, Professor of Physics, at Chemnitz, who, in 1870, communicated to the *Repertorium für Experimental Physik* the details of an experiment on the transmission of the human voice by means of an iron wire.

THE COLONY OF VICTORIA.—The statistics of this colony published up to the end of 1877 give very complete information as to the telegraphic administration of this part of our empire. Telegraphic communication exists in Victoria between 206 stations within her own borders. Her lines are connected besides with the lines of New South Wales, and by means of them with Queensland and New Zealand. They are also connected with the lines of South Australia, and by their means with the Eastern Archipelago, Asia, Europe, and America. They are likewise united with a submarine cable to Tasmania. The lines were extended during the year 1877 by 142 miles, and 455 miles of wire were added to that previously existing.

GAUSS AT GOTTINGEN.—In 1833 the attention of Gauss was called to the theoretical consideration of the earth's magnetism, but he found himself soon arrested by the want of accurate and extensive data. He instituted, accordingly, a magnetic observatory at Gottingen, and, having furnished it with new instruments, began observing in March, 1834. Co-operation was sought and obtained in various parts of the Continent; a more intimate alliance was formed between the several points of observation; and, after various modifications in the time and mode of observing, the amount of which was, to make the observations more minute and the number of terms smaller, one day in the months of February, May, August, and November was selected, in which observations were to be made at every five minutes during the twenty-four hours.

ELECTRICAL POTENTIAL.—In connection with the article under this heading in our present issue, the following extract from a biographical notice of Gauss in the *Panthéon de Electricité* will be of interest to the theoretical student. The writer of the notice in question does not seem to be aware of the use of the term potential by the mathematician Green. "Unfortunately, the invasion of physical science by the algebraists, who forget that mathematical science is a slave which has only to obey, is partly due to the influence of Gauss. It was he who invented the term *potential*, to which it has vainly been endeavoured to give a physical signification. In fact, if this analytical expression had any objective reality, it would lead to the conclusion that the attraction between two points in absolute contact would be infinitely great, which is manifestly absurd."

THE ELECTRIC LIGHT IN SALT MINES.—The practical utility of the electric light for illuminating salt mines was tried in Messrs. Verdin and Sons' rock salt mine at Marston, in Cheshire, on Thursday week, the experiments being conducted by Messrs. Welch and Scott, of Manchester. The mine is one of the largest in England; its capacity is about seven or eight acres, being a gigantic space, the roof of which is supported by natural pillars of rock salt. Up to the present time, no more effective means of lighting mines have been found than the use of tallow candles. This, in other words, means almost total obscurity, the workmen having to find their way about more by instinct than anything else. Even this feeble illumination is more costly than that given by the electric light. In Thursday week's experiments the electric light was generated from a Siemens machine, the motive power being derived from Marshall's special electric engine. The light was very powerful, and the result was satisfactory in every way, the workmen being able to carry on their mining operations with the greatest facility. From the successful result of this experiment a general use for this purpose may be predicted.

UNDERGROUND *versus* OVERHEAD TELEGRAPH LINES.—In a recent article on this question, a correspondent of the *New Free Press* of Vienna quotes a very important testimony by Count von Moltke in favour of that system of telegraphy which is least liable to interruption from accidental causes. "If, at the period when war was declared by France," said the German strategist, "a storm had broken down our telegraph lines at only five or six points, our system of mobilisation would have remained a theoretical machine, and no human power could have prevented the enemy from making his way to the Rhine." In the same article it is pointed out that the frequent repairs necessary in the case of overland lines probably render them, in the long run, as costly as underground wires, and that the fact of the former being so liable to attack by evil-disposed persons, and to be disabled in times of political disturbance, is a very grave objection against them. The geological conformation of North Germany, says the writer, renders it admirably adapted for a system of underground lines, since, throughout its immense plains, the trench for the reception of a cable could be made by means of a plough of special construction.

A CURIOUS THERMO-MAGNETIC MOTOR.—Profs. Houston and Thomson contribute a note on this subject in the *Journal of the Franklin Institute*. During investigations on the increase in the coercitive force of steel by changes of temperature, they devised a thermo-magnetic motor, which, however, they state to be only of scientific interest. A disc or ring of thin steel is mouuted on an axis. The edges of the wheel are placed opposite the poles of a horse shoe magnet, and the wheel is thus magnetised by induction. The singular phenomena is that any section, say midway between the N and S poles, being sufficiently heated, the disc revolves in the direction from S pole to N pole. The heated section, say the authors, has its coercitive force increased, and being less acted upon by the S pole than the section immediately adjacent, motion in the direction previously indicated takes place. To ensure success the disc must be sufficiently thin as to prevent its acquiring a uniform temperature. The same effect takes place if the source of heat is applied to diametrically opposite portions of the disc. The amount of heat expended is enormous when compared with the force developed, so that no practical result is expected to arise from this discovery.

DR. S. M. PLUSH'S BATTERY CELL.—This battery cell is a

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modification of the Callaud battery, and consists of the glass jar of the usual proportions, having at the bottom a copper plate upon which is placed sulphate of copper, and has attached to it an insulated wire forming the positive pole. About half way down the inside of the glass jar is a perforated sheet of copper, forming a shelf upon which is placed pieces of zinc of any form. The shelf is suspended by three strips of copper, one of which constitutes the negative pole. With this form of cell the zinc of commerce can be broken into pieces of suitable size and used without any other preparation, and the zinc can all be consumed; while in the Callaud battery the zinc must be cast into suitable form, involving some loss of metal and expense, and as a considerable percentage of the zinc of such castings is not consumed it must be remelted at still further loss. Another advantage is that the sulphate of copper can be fed into the bottom of the cell through the opening left by turning up one side of the shelf, and broken zinc placed upon the shelf without disturbing any of the connections, thus making the battery absolutely continuous. Objection has been urged that there will be local action between the zinc and the copper of the shelf, but Dr. Plush holds that practically no such action can take place, as there is really no closed circuit between the pieces of zinc and the copper. Lead may be substituted for copper in making the shelf.

THE TELEPHONE SUITS.—The Gold and Stock Telegraph Company (says the *Operator*), in its answer filed in the suit brought against it by the Bell Telephone Company, sets up the general claim that the telephone is not a new invention, and that Gray was the prior inventor. The Boston case, it is thought, will reach trial by April or May. The Bell Telephone Company has obtained injunctions against several smaller manufacturers of telephones, and suits against others are pending. The company is turning out fifteen hundred telephones a month, and orders are so numerous that many are more or less delayed. There are now 17,500 instruments out, and 15,000 actually rented. Instruments are supplied principally to Telephonic Exchanges, which are being rapidly introduced into all the larger cities. At Albany and Troy there are 350 instruments in circuit, at Buffalo there are 250 subscribers, at Detroit about 150 instruments in circuit, at Chicago 550, at Indianoplis 150 subscribers, at St. Louis 325 instruments in circuit, at Cincinnati 200, at Philadelphia 500 subscribers and 250 instruments in circuit, at Columbus 200 subscribers and about 50 instruments in circuit, at Baltimore 300 subscribers, 100 instruments in circuit; at Washington, New Orleans, Louisville, and Nashville, Exchanges are being started. In Boston there are 500 subscribers and about 150 instruments in circuit, at Lowell 200 instruments in circuit, at New Haven 350, at Bridgeport 175, and at Springfield, Hartford, and Providence Exchanges are being started. An Exchange has just been started in this city, where there are at present about 750 subscribers and about 250 instruments in circuit.

ON AN AUTOMATIC CURRENT-REGULATOR, BY M. HOSPITALIER.—The apparatus which we have the honour to present to the Academy is composed of a resistance-coil wound in one layer only, the wire of which has been denuded along a generatrix of the spiral over a width of about one centimetre. A lever, somewhat convex, and forming a divider, is applied to the denuded part of the wire. This divider is attached at one of its extremities to an armature placed before an electro-magnet, in which the current circulates which is to be regulated. An antagonistic spring supports the lever at its other extremity. The circuit is formed by the resistance-coil, the lever, and the electro-magnet. The apparatus being regulated for a determined intensity, the divider introduces into the circuit a certain number of turns of the coil. If the current increases in intensity, the electro-magnet attracts its armature more strongly, the divider shifts its fulcrum and introduces into the circuit a greater number of turns of the coil; the resistance increases, and the intensity is diminished. The opposite effect is produced if the intensity of the current diminishes. By suitably regulating the force of the antagonistic spring, the electro-magnet, the distribution of the wire upon the bobbin, and the curvature of the divider, we can render the system astatic; and then the apparatus gives a mathematically constant current. In practice we can maintain the intensity of the current between two limits fixed beforehand, and as close as we will. From an industrial point of view, the apparatus can be applied to electro-typing, to the incandescence of wires of platinum or iridium (to prevent their fusion), and, if the problem should one day receive its practical solution, to the distribution of electricity in dwelling houses, where the apparatus will play the part of a real meter and divider of the electric current.—*Comptes Rendus de l'Académie des Sciences*, Dec. 9, 1878, t. lxxxvii. p. 920.

THE TELECTROSCOPE.—M. Senlecq, of Ardres, has recently submitted to the examination of MM. du Moncel and Hallez d'Arros a plan of an apparatus intended to reproduce telegraphically at a distance the images obtained in the camera obscura. This apparatus will be based on the property possessed by selenium of offering a variable and very sensitive electrical resistance according to the different gradations of light. The apparatus will consist of an ordinary camera obscura containing at the focus an unpolished glass and any systen of autographic telegraphic transmission; the tracing point of the transmitter intended to traverse the surface of the unpolished glass will be formed of a small piece of selenium held by two springs acting as pincers, insulated and connected, one with a pile, the other with a line. The point of selenium will form the circuit. In gliding over the surface, more or less lightened up, of the unpolished glass, this point will communicate, in different degrees and with great sensitiveness, the vibrations of the light. The receiver will also be a tracing point of blacklead or pencil for drawing very finely, connected with a very thin plate of soft iron, held almost as in the Bell telephone, and vibrating before an electro-magnet, governed by the irregular current emitted in the line. This pencil, supporting a sheet of paper arranged so as to receive the impression of the image produced in the camera obscura; will translate the vibrations of the metallic plate by a more or less pronounced pressure on that sheet of paper. Should the selenium tracing-point run over a light surface the current will increase in intensity, the electro-magnet of the receiver will attract to it with greater force the vibrating plate, and the pencil will exert less pressure on the paper. The line thus formed will be scarcely, if at all, visible; the contrary will be the case if the surface be obscure, for, the resistance of the current increasing, the attraction of the magnet will diminish, and the pencil, pressing more on the paper, will leave upon it a darker line. M. Senlecq thinks he will succeed in simplifying this apparatus by suppressing the electro-magnet and collecting directly on the paper by means of a particular composition the different gradations of tints proportional to the intensity of the electric current.

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PROF. GIULIO CERADINI'S ELECTRIC SIGNAL FOR THE PREVENTION OF RAILWAY COLLISIONS.

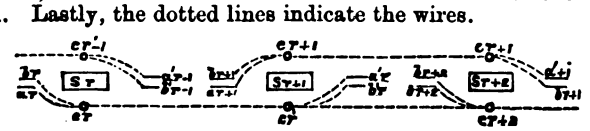
It is now all but certain that the trial of Ceradini's Signal will take place forthwith, on the line between Genoa and Spezia. This line, from the difficulties which it presents, is well calculated to afford a crucial test to an instrument of which, from the ingenuity of its construction and the result of the preliminary trial, the best may be augured. The proof is to extend over an entire year, and must issue either in the sanction of practical success being accorded to the invention, or in a revelation of its possible defects. In the latter case we are confident that Professor Ceradini will find no difficulty in providing a remedy.

In anticipation of these experiments our readers will probably welcome a description of the apparatus. We ourselves, thanks to the courtesy of Prof. Ceradini, are in possession of the minutest details; at his express wish, however, we refrain from publishing more than a general outline of the apparatus, but this, we believe, will be sufficient to demonstrate its superiority over the many others designed with the same object, namely, the prevention of railway collisions.

At the two ends, then, of each station, at a distance of about half a mile, are placed between the rails and parallel to them two contacts, which we will call road-contacts, consisting of two rods completely insulated from the earth, and covered with metal on the upper surface. At the side of the line, and in connection with the middle of the two contacts is placed another rod bearing a disc brightly coloured and furnished with a lamp at night, as a fixed signal. When the locomotive of a train approaching the station from either side reaches the rod a steam whistle is blown, having a peculiar sound, which announces that the line is clear and that the train can proceed. At the same time, two signal-squares, the one at this station, the other at the following one, indicate that the portion of line between them is occupied. If the whistle fails to sound, it means that the section on which the train is moving already contains another—either stopping at the next station or in course of transit from that to the succeeding one. The signal is given in ample time for the driver to pull up and thus avoid a collision.

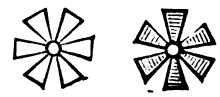
Before indicating by what means these results are obtained, we may point out an advantage of the utmost importance which is peculiar to the system we are describing. As a rule, the electric apparatus, some of them very ingenious, which have been designed to avert railway collisions, have been constructed to give a signal either visible or audible in the event of imminent danger. But such occasions occurring but seldom, these instruments always run the risk of failure at the critical moment through some simple fault which it might be very difficult to discover beforehand. The trust, therefore, reposed in them may not only prove illusory but gravely prejudicial. The rupture, detaching, or oxidation of a wire, the wasting of the zinc, or evaporation in the battery, and a thousand other disturbing causes well known to all who are familiar with electrical apparatus, make it, indeed, but too probable that such will be the case. In Ceradini's system, however, the simple organs of the apparatus are bound to work every time a train arrives at a station and also, as will be seen, every time it departs, and this ensures the whole being constantly in perfect order. "Line clear" is signalled to the engine driver, as already stated, by a whistle; silence, on the other hand, tells him of an obstruction, and warns him to stop. The whistle, it is true, might fail through a fault in the instrument; but it is evident that the consequent stoppage of the train would not expose it to any risk, whilst the proximity of the station would enable it to be discovered at once whether there was a fault in the apparatus or a block on the line.

Turning now to our description, we will commence by giving in the following figure, a plan of the electric connections. The rectangles S_r, S_r+1, S_r+2, represent three consecutive stations; the circles c_r, c_r-1 the two signals at the station S_r; c'_r, c_r+1 those at S_r+1; and c'_r+1, c_r+2 those at S_r+2. The larger marks, a_r, b_r, a'_r-1, b'_r-1, a_r+1, b_r+1, a'_r, b'_r, &c., represent the pairs of road contacts at the two ends of each station. The contacts to the right of an approaching train, whatever its direction, are marked by the letter a, qualified by a sign or number, whilst those to the left have the letter b with the same sign. Lastly, the dotted lines indicate the wires.



It will be seen at once from this plan that the electric line is divided into sections which overlap one another, but remain, nevertheless, entirely distinct at their extremities; each section commences at the signal rod placed before the station where the two road contacts, for example a_r, b_r, are placed in connection with the signal c_r of the same station. This signal is further put in connection, by means of the telegraphic wire with the signal c'_r of the following station, which in a similar way communicates with the contacts a'_r, b'_r behind the latter. In like manner, the signal c_r-1, with the contacts a'_r-1, b'_r-1, represent the end of the section commencing at the station preceding that of S_r; whilst the signal c_r+2 and the road contacts a_r+2, b_r+2 belong to the section between S_r+2 and the succeeding station. The section between the signals c_r+1 and c'_r+1 reproduces symmetrically on the road the disposition of that which connects c_r with c'_r. Each of the signals presents to the observer a square face, of about a decimeter each side, in which are cut regularly round the centre six windows, equal in size, and in form parts of sectors of circles.

Behind the face is a disc which revolves on its centre in a plane parallel to that of the face, its front being divided into twelve equal sectors painted alternately white and red. When the white sectors of the disc coincide with the windows of the signal face, which then shows all white, it means that the line is clear to the succeeding station; if, however, the red star appears, owing to the coloured sectors coinciding with the windows, it signifies that the line is already occupied. The disc is set going by a clockwork motion, which is wound up once or twice a year; but an escapement wheel of ingenious construction controls it, and only permits it to complete a twelfth-part of a revolution at a time, so that at each movement the different sectors appear at the windows, red and white alternately. At the two sides of the clock are placed two horseshoe electro-magnets, which work upon the escapement and produce the requisite effect, and matters are so arranged that when a signal—for example, c_r—receives a current from the right road contact a_r in the preceding station, this current excites one of the electro-magnets, which produces the red star; the same current transmitted by the wire c_r, c'_r excites at the same time the corresponding electro-magnet at the succeeding station S_r+1, producing the red star on the signal square c'_r, and then, without continuing to the contacts a'_r, b'_r, goes to earth. Through a special construction of the commutator, which connects the pair of road contacts with the coils of the two electro-magnets, when a current coming from the contact a_r has produced the movements indicated, any other current coming from the same contact, or from the contact a'_r at the other end of the section, is intercepted from the two signals, which, therefore, continue to show "line blocked" until a current from contact b_r or b'_r, exciting the second electro-magnet shall have caused the disc to revolve to the alternative sectors, and replaced signals c_r, c'_r at "line clear." Thenceforth the commutator intercepts the currents coming from the left-hand contacts and re-establishes the connections with those to the right. To recapitulate, we may say, then, that the two electro-magnets are actuated respectively, the one by the currents coming from the right-hand contacts a_r, a'_r, the other by the currents coming from the left-hand contacts b_r b'_r; that the first causes the red signal to show, whilst the second obliterates it; that, in fine, the two electro-magnets work alternately, because the commutator whence they receive the current is so arranged as to intercept from the line the electro-magnet which has last worked and include, in its place, the other one. When this, in turn, has received the current, the connection is once again inverted.



"Line Clear." "Line Blocked."

We now come to the origin of the currents which work the four signals. On the floor of the locomotive is a battery of Leclanché cells, from which a wire is soldered to the body of the locomotive, and thence, by way of the wheels and rails, put constantly to earth. The other wire is joined to one end of the coil of a Hughes electro-magnet, placed on the boiler, and this, its own armature being detached by the force of the opposing spring, when the current is induced, opens a valve, and lets the steam into the whistle, thus telling the driver that the line is clear. The magnetic attraction lowers the armature once more as soon as the current is intercepted. The other end of the coil of the electro-magnet is joined to a wire, completely insulated from the locomotive, which terminates under the flooring between the wheels in a spray of wires so disposed as to brush the right road contacts. If the station approached be S_r+1, the contact brushed will be a_r+1 or a'_r, according as the train is coming from S_r or S_r+2. Thus the same current which, when opposite the signal rod, sounds the whistle, also moves the discs of the four signals at the near station and the next beyond it. To make the matter clearer, let us suppose that the train is coming from S_r, and that, at the time when it approaches S_r+1, there is no obstruction on the section S_r+1, S_r+2, so that the signal squares c_r+1, c'_r+1 show white, whilst that of c'_r indicates, by the red star, the pre-

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sence of the train on the line between S_r and S_{r+1}. The spray of wires brushing the contact a_{r+1} will sound the whistle, and simultaneously the red star will appear on the squares c_{r+1}, c'_{r+1}. Any train arriving now from the same direction would not get the signal "line clear" from its whistle, since the commutator of c_{r+1}, c'_{r+1} would have already interrupted the connection with the contact a_{r+1}, and one of the wires being insulated, the current could not become established. This second train would thus be warned of the presence of the preceding one. If, on the other hand, whilst the first train approaches a_{r+1} another is in course of transit between S_{r+1} and S_{r+2}, or stopping at either of these stations, by the brushing of the latter's spray against the contact a'_{r+1}, or, as the case may be, a_{r+1}, a_{r+1} will have been cut off from all connection with the squares c_{r+1}, c'_{r+1} and insulated from the earth, so that the whistle would fail to sound. The squares c_{r+1}, c'_{r+1}, at the same time, would keep steadily at "line blocked." When the train that has come from S_r leaves the station S_{r+1} its spray will brush the left contact b'_r, and the current thus transmitted from the squares c'_r, c_r will replace the signal at "line clear," whilst the interrupters re-established connection with the right contacts a_r, a'_r.

Unless we have failed to express ourselves sufficiently clearly, the reader will gather, then, that things are so arranged that the approach of a train to any station produces there and at the following one the signal "line blocked," whilst the departure of a train from any station leaves the signal "line clear" there and at the preceding one. In fact, the indication of "line blocked" on the section occupied is produced at one and the same time with the signal "line clear" on the preceding section. The two squares placed at each station, and belonging to the sections between it and the stations next on either side, signal constantly whether the one or the other section is occupied, whether they are both free, or whether they are both blocked. All this is done, too, clearly and surely, for, as premised, the apparatus is in constant use, and, therefore, under thorough control.

A slight modification in the disposition of the right contacts has enabled the inventor to obviate the inconvenience arising from the use of the method here described in the case of a slow or goods train arriving at a station in front of an express, to which it ought to yield precedence. The express would get, on arrival at the station, the signal showing the line blocked in front of it, but there would be no indication as to the nature of the obstruction. The modification we have mentioned works in this way—If the line is clear as far as the succeeding station, the express on starting again hears the safety whistle which had failed to sound on its arrival. If this whistle is again silent it signifies a block, and warns the driver to pull up and wait till the line is cleared. R. FERRINI, in *La Natura*.

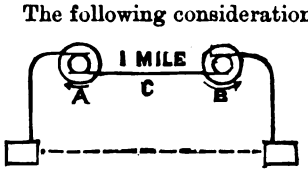
ON THE TRANSMISSION OF POWER BY MEANS OF ELECTRICITY.*

BY PROFESSORS ELIHU THOMSON AND EDWIN J. HOUSTON.

The statements recently made as to the size and cost of the cable that would be needed to convey the power of Niagara Falls to a distance of several hundred miles by electricity, have induced the authors to write the present paper, in the hope that it may throw light upon this interesting subject. As an example of some of the statements alluded to, we may cite the following, viz., that made by a certain electrician, who asserts that the thickness of the cable required to convey the current that could be produced by the power of Niagara would require more copper than exists in the enormous deposits in the region of Lake Superior.

Another statement estimates the cost of the cable at about $60 per lineal foot. As a matter of fact, however, the thickness of the cable required to convey such power is of no particular moment. Indeed, it is possible, should it be deemed desirable, to convey the total power of Niagara, *a distance of* 500 *miles or more*, by a *copper cable not* exceeding one-half of an inch in thickness. This, however, is an extreme case, and the exigencies of practical working would not require such restrictions as to size.

The following considerations will elucidate this matter:—Suppose two machines, connected by a cable of, say, one mile in length. One of these machines, as, for example, A (*see* Diagram), is producing current by the expenditure of power; the other machine, B, used as an electrical motor, is producing power by the current transmitted to it from A by the cable C. The other terminals, x and y, are either put to earth or connected by a separate conductor.



Let us suppose that the electromotive force of the current which flows is unity. Since by the revolution of B a counter electromotive force is produced to that of A, the electromotive force of the current that flows is manifestly the difference of the two. Let the resistance of A and B together be equal to unity, and that of the mile of cable and connections between them the ·01 of this unit, then, the current which flows will be $C = \frac{E}{R} = \frac{1}{1.01}$. If, now, an additional machine A', and an additional motor B', and an additional mile of cable be introduced into the above circuit, the electromotive force will be doubled, and the resistances will be doubled, the current strength remaining the same as $C = \frac{E}{R} = \frac{1+1}{1{\cdot}01+1{\cdot}01} = \frac{2}{2{\cdot}02}$. Here it will be seen that the introduction of the two machines A', B', has permitted the length of the cable c to be doubled, without increasing the strength of the current which flows, and yet allowing the expenditure of double the power at AA', and a double recovery at BB' of power; *or, in other words, a double transmission* of power, without increase of current. Increase, now, the number of machines at A to, say, one thousand, and of those at B in like proportion, and the distance between them or the length of the cable, one thousand, or in the case we have supposed, make it one thousand miles, its diameter remaining the same. Then, although the same current will flow, *yet we have a thousand times the expenditure of power at one end of the cable, and a thousand fold recovery at the other end, without increase of current.* And the same would be true for any other proportion.

Since the electromotive force is increased in proportion to the increase of power transmission, the insulation of the cable and machines would require to be proportionally increased.

As an example, it may be mentioned that a dynamo-electric machine used for the purpose of A in the figure may have a resistance of, say, 40 ohms, and produce an electro-motive force of, say, 400 volts. Such a machine might require from three to five horse-power when used in connection with a suitable motor B, for the recovery of the power transmitted. If the resistance of the motor B be, say, 60 ohms, and the cable transmitting the currents a distance of one mile, be one ohm, then the current $C = \frac{400}{6+40+1} = \frac{400}{101}$. If now one thousand machines and one thousand motors, and a thousand miles of cable, each of the same relative resistances be used, the current $C = \frac{1000 \times 400}{1000 \times 101}$, which has manifestly the same value as before. If our supposition of the power used to drive one machine be correct, then from three to five thousand horse-power would be expended in driving the machines, and possibly about fifty per cent. of this amount recovered. Then we have from 1,500 to 2,000 horse-power conveyed a distance of 1,000 miles. What diameter of copper cable will be required for such transmission? Since this cable is supposed to have the resistance of one ohm to the mile, calculation would place the requisite thickness at about ¼ inch. If, however, the distance be only 500 miles, then the resistance per mile may be doubled, or the section of the cable be decreased one-half, or its diameter will be less than the 1-5 inch.

For the consumption of 1,000,000 horse-power a cable of about three inches in diameter would suffice under the same conditions. However, by producing a much higher electromotive force, the section of the cable could be proportionally reduced, until the theoretical estimates, which we have given in the first part of this paper, might be fulfilled. The enormous electromotive force required in the above calculation would, however, necessitate such perfect insulation of the cable that the practical limits might soon be reached. The amount of power required to be conveyed in any one direction would, of course, be dependent upon the uses that could be found for it; and it is hardly conceivable that any one locality could advantageously use the enormous supposed power we have referred to.

Stripped of its theoretical considerations, the important fact still remains that, with a cable of very limited size, an enormous quantity of power may be transferred to considerable distances. The burning of coal in the mines, and the conveyance of the power generated by the flow of rivers, may, therefore, be regarded as practicable, always, however, remembering that a loss of about 50 per cent. will be almost unavoidable.

[It may be mentioned that Dr. C. W. Siemens and Sir William Thomson have recently made statements that are in general accordance with the views here expressed.]

* *Journal of the Franklin Institute*, Jan., 1879.

TELEGRAPH MUTUAL BENEFIT ASSOCIATION, NEW YORK.—The number of members of this excellent Association is 1886.

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THE ELECTRIC LIGHT AND "SOCIETY."

(FROM A CORRESPONDENT.)

Professor Tyndall has at length delivered his lecture at the Royal Institution. We have described a similar gathering at the Society of Arts, where the electric light showed its paces before what is called the public. Professor Tyndall, farther westwards, has now introduced it to society. We have no desire to draw inviduous comparisons between the lecturer in the Adelphi, and that at the more illustrious institution; and, indeed, as will be seen presently, the facts do not call for it; but the respective audiences were conspicuously different. There, a miscellaneous crowd, chiefly men, hurried to see and hear something to guide them in the practical affairs of life as concerning the new light. Here, we had a decorous assemblage of ladies in evening costume, with or without male escort; and, although a great many learned men were present, by comparison of numbers, they only served to keep up the character of the place. Nobody shouted, nobody asked questions, and the applause, if there were any, was of the genteelest sort. Only from the subdued comments of those around us, and from the little grimace of fear or delight, half hidden by a fan, could one gather whether things were going well or ill for the audience. But if we try to put ourselves in its place, use our eyes vigilantly, and still listen to the lecturer, we may draw some fairly reliable conclusions as to the effect produced. The theatre was full nearly an hour before the time appointed for the lecture. That the subject attracted so large an audience is not surprising. Whether Professor Tyndall is himself a popular lecturer we shall, perhaps, be able to determine as we proceed. We will describe in general outline, but with sufficient exactness, what was actually said and done, apart from any report of them which has appeared in the papers.

The lecturer began well, gratefully acknowledging his indebtedness to the persons who had brought together such an array of appliances. He then gave a concise account of the history of the electric light up to recent times; and straightway performed the familiar experiment with a battery and heated conducting wires. The well-chosen words, the carefully-constructed sentences, and the precision with which the laws were set forth relating to the voltaic pile and the generation of heat inside and outside of it, were all very admirable. Many a grave and knowing head was seen gently moving in sympathy with the musical rythm of the speaker's utterances; and the bent attitude betrayed expectancy that when these quite familiar matters were disposed of something new would be forthcoming, or that old facts would receive some fresh and novel signification. Not so, however; the descriptions and experiments went on for an hour or more, and all the men—except, perhaps, the weaker brethren who sat with the strong-minded females—might just as profitably have gone to sleep. But the non-learned part of the audience were very numerous and had to be entertained somehow; so we will turn to them, leaving the *savans* to their disappointments.

There were two, and only two, satisfactory courses open to an experienced lecturer in circumstances like these. He might assume his hearers knew all about first general principles, and proceed to their application; or he might take it that his hearers knew nothing, and, scrupulously explaining elementary principles, rapidly pass over intermediate stages to their final application. Professor Tyndall followed neither. He had prepared his exordium and peroration, had formulated his statements of the conversion of voltaic or muscular forces into electrical or magneto-electrical heat, but for the rest he had trusted to chance. It never was quite clear whether these formulas had been prepared for preliminary texts or for summings up; they were repeated with tedious frequency, but repetition without amplification made nothing clearer. In one case—that of the "give and take" of dynamo-magnetic machines—even his formulas broke down; and we fear that his "knowing nothing more beautiful" with ever so winning an accent scarcely awoke the responsive interest which, had it been described with simple-minded painstaking, it should have evoked. "It was very difficult to follow," we heard from more than one quarter in tones more self-reproachful than were called for. A sensational abstract speculation, with a rude jump backwards to the initial discovery that gave rise to it, is not exactly the way either to teach the simple or edify the wise. Yet this was the method in at least one notable instance where the supposed influence of the magnetic lines of force upon a closed coil of wire was abruptly followed by a quite inadequate explanation of Faraday's original magneto machine.

We have felt constrained to make these comments on the lecture itself, because the opportunity was a great one, and in the hands of a man accustomed to weigh well what he ought to do, and what he would be able to do in a given time, it would have been made a great success. Evidently the intention was to be popular. We say nothing as to the propriety of the choice; but as the lecture was certainly not scientific, it is to be regretted that it was not the other thing. It doubtless satisfied the curiosity of many who wished to make a closer acquaintance with electric lamps; and of those who wanted to see and hear the man who, in his maturer years, has contrived to make a commotion whenever he has spoken; who has made science palatable in literature, and scepticism "respectable." But this, so far as was to be seen, was the sum total of the interest excited.

The experiments were well arranged, and, with one exception, very disconcerting to the lecturer at the outset; they went off good naturedly. Rapieff's lamp was most favoured, and it showed to advantage, save perhaps in calling forth an armoury of fans to protect eyes in its neighbourhood. The ingenuity displayed in the construction of this and the several other lamps was dilated upon; but no attempt was made to set a value upon them either from the illuminating or economical point of view. The place of honour, if the place of severest trial can be so called, was, of course, given to the Siemen's lamp, one of which, suspended about half way from the ceiling, gave sufficient light for the whole space. As there are deep overhanging galleries at the Royal Institution, some parts of the audience were under illumination more searching than the clearest daylight, while others were in comparative obscurity; so that a generally accurate opinion could be formed of its adaptability to purposes of that sort. It was decidedly unsteady, and unsteadiness in such a volume of light means all the difference between dimness and dazzle. That it disturbed the speaker's nerves as well as those of his auditors was obvious, and it accounted for the confused way in which some of the business was got through. But the primary mistake was, if not in taking up the subject in that spirit, in acting like an advocate. We hope that future lecturers will have the courage and good sense to say in effect, "You want to see this light; here it is at its best, and at its worst; I am here to explain, not to belaud it." But this was not Professor Tyndall's *rôle*. He had evidently made up his mind to claim the electric light as a marvellously promising child of science, sure to grow up a prodigy; and whose every blink and awkward gesture, therefore, gave him the utmost anxiety. Considering how much mechanical invention has had to do with its resuscitation, and how extremely little science has aided it, there was little need for solicitude and small grounds for this sudden warmth of paternity on the part of the scientist. If ever there was a time, however, when science should have established its credit and told us what there is to know about the future of the electric light it was on this occasion. But the opportunity was lost. "The laws," said the lecturer, "are all perfectly well known to us;" and in the same breath uttered some vaguely prophetic allusion to "the land which has given us the sewing machine, the phonograph, and the electric pen," as likely to give us something new, and therefore presumably something we do *not* know." He seemed pretty confident of its adoption for general out-of-door purposes; but he "was not so sure" about indoor illumination—why he was not so sure, or why he was sure in the other case, he did not explain. Once we really thought we were coming to something new, when Mr. Ladd lit up the room with incandescent iridium. This was the event of the evening. Here was the steadiest, the warmest, and therefore the most agreeable light that had been shown. The assistants were ready with appliances illustrative of incandescent lighting; and the knowing ones awoke from their mental slumber. But giving a glance at the hour, which had stolen past ten, the lecturer assured us that we knew all about it; and with that comprehensive waive of the hand which public speakers resort to when their physical or mental stamina has failed them, he dismissed the whole subject, and launched into his peroration.

But whatever impression the lecturer may have made, that left by the light was in one respect unmistakable. We hear of it being introduced into clubs; but we doubt if it receive an invitation to the drawing room. Women, we are thankful to say, learning notwithstanding, still value their good looks, and are not likely to sacrifice them on the altar of science if it happen to make them appear ghastly. If the shutters were suddenly flung open, and a flood of broadest daylight poured in upon a fashionable assembly unexpectedly overtaken by the morning, the aspect could not be more woebegone than that exhibited under the electric light. Colours we are told remain unimpaired; but we should hardly dare tell a lady so "to her face;" and if she have a choice in the matter she will assuredly vote for the unveracity which pays most respect to her complexion.

OVERLAND LINES IN BAD WEATHER.—We hear that, in consequence of the weather which has prevailed latterly, many of the overland lines in France completely broke down, giving great trouble to the administration.

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THE ELECTRICIAN.

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ARE MORE ATLANTIC CABLES REQUIRED?

At present the answer to such a question must be emphatically and distinctly—No. We are not yet fully cognisant of the whole history of this attempt to float a company ostensibly for the purpose of laying two more cables to cross the Atlantic; but there are sufficient indications to show that it is the act of parties interested in putting every conceivable difficulty in the way of existing companies. The feeble endeavours to show that such cables are required would be contemptible were they not mischievous. The inducements put forward to gain the aid of speculators are of the wildest description, and will not bear the light of day. On hearing of the revival of this scheme, which undoubtedly did not originate in France, we made enquiries as to the objections to be brought against the existing cable companies. Were the lines overworked? Not so; but far from this being the case we found that the present cables were capable of doing at least double the amount of work they are now called upon to perform. Further, early last year the "Direct United States Cable" was duplexed, and thus its carrying capacity increased. We believe we are correct in saying that the existing business has hardly as yet called into play the increased capacity of this cable. At the end of the year we were informed that the "Anglo-American Company" had its cables duplexed; as yet, however, the inventor has not handed over the working to the company, but supposing success to be obtained, as it must be by one system or the other, we shall obtain still greater message-carrying capacity. If then the existing cables under existing circumstances are working well within their means, and if this now latent power of increased sending is ready whenever called upon, where is the necessity for more cables. Having so far disposed of the question of ability to carry messages, let us turn to that of charges. The assumed receipts of the new company are calculated upon the same charge per word as with the existing companies, so that it is evident the reason for promoting the new concern is not from the complaint of "too high a tariff." Unless the tariff is decreased, the argument that increased facilities will bring an increase of business is untenable. There is, in fact, no increase of facility. The sender of a message would then as now have to go to some telegraph office to send his message, which would be forwarded for exactly the same amount in the same time. Where then is the gain to the sender, or the inducement to increase the length or number of his messages? The absurdity of the whole scheme becomes clearer and clearer the more it is examined. Let us proceed, however, to another question. According to our argument, the laying of one, or two, or two hundred new cables will have no tendency to inrease the number of messages. Assume that the cables are laid. The existing capital is about eight millions sterling. This capital is to be increased by two millions, the receipts remaining pretty constant. We have looked carefully into the question of receipts and expenditure, and it seems clear that with the increased capital, increased working expenses, and increased reserve, the shareholders will find that scarcely any dividend can be obtained. Of course the case is still worse if competition should lead to the lowering of tariffs. Will the lowering of the tariff bring increased business? It will not. The business is not there to bring, and it is absolutely impossible to bleed a stone. The messages now sent by cable mostly belong to one or other of three classes—those sent for the Government, those for the Press, and those for commercial purposes. The Government is allowed to send cypher telegrams, and with these we have not to deal. It is hardly to be expected that the Press will increase the number of messages sent, inasmuch as it already enjoys an extremely low tariff, and the limit, even to newspaper energy, is almost reached. Home news must of necessity always form the larger part of newspaper material, and hence the limitation of space implies the limitation of telegrams. The commercial world has learnt to "pack" messages so that it is doubtful if any one is really acquainted with the exact "tariff" per word paid for such messages. In a large number of cases a "word" simply stands for a complete sentence, so that the payment for a word is really the payment for a sentence. In our issue of the 4th of January we gave the translation of an article which appeared in the Paris *Soir*. It will not be out of place to again repeat one or two of the sentences that article contained. Referring to the "Direct" cable, we read:—"The loss suffered by the Syndicate in England

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having exceeded 500,000*l.* sterling, one is a little astonished at the boldness of English constructors and their agents in seeking to tempt Paris houses once more by a project which the London Exchange, enlightened by the sad experience of the past, considers absolute folly." If the suggestion in this sentence is correct, and an English firm is found to be the promoter of the scheme, there is no difficulty in understanding why they should go to French capitalists.

The prospects of success have been well discounted in London, and pronounced hopeless. In France the promoters probably expect to mature their plans without searching investigation, but our contemporary, *l'Electricité*, is not likely to overlook such considerations as we have pointed out. In a short article on the subject, we find it is stated that several interesting communications have been sent to the editor, but he withholds their publication till better informed as to the real state of affairs. The writer of the article states that the scheme mooted in 1876 was, in effect, abandoned, and that the consideration of this revival demands great circumspection. It may safely be inferred that the capitalist will refrain from supporting this scheme, because the syndicate that floated the Direct Cable found the balance considerably on the wrong side, whilst after the proved success of the agreement giving that Company one-fourth of the receipts received for Transatlantic messages, the shares are worth no more than 11*l.* or 12*l.*, instead of the par value 20*l.* Add to these facts, experienced within the last few years, those already noted, viz., that existing cables have a large margin of working power, that the tariff is not found exorbitant, and that trade is altogether depressed, and we think that hardly a single share in such a scheme as that we have been commenting upon would be taken on this side of the Channel. *Nous verrons.*

CORRESPONDENCE.

CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg leave to offer to you a reply to the two letters published in *The Electrician* of January 24, one signed "Scrutator," originally published in the *Daily Telegraph*, January 9th, the other in the *Times*, January 21st, signed "Robert Lorimer."

A categorical reply to the several queries of Mr. Robert Lorimer will serve also as an answer to the statements of "Scrutator." In fact, the similarity of the two letters leads one to believe that they are the inspirations of the same mind.

To the first interrogatory, "Why is the capital so large as 2,080,000*l.*, when the total cost of two cables in working order need not exceed 1,500,000*l.* or 1,600,000*l.*?" I beg to offer as to the cost of a cable of 3,000 miles the report of the directors of the Anglo-American Telegraph Company at the annual general meeting in February, 1864.

The directors therein say, "they have 900 miles of deep sea cable worth 300,000*l.*," and also "a contract had been entered into with the Telegraph Construction Company, by which for the sum of 475,000*l.*, they had undertaken to manufacture 1,100 miles of new cable, and lay it together with the 900 miles already possessed by the company, between Valentia and Newfoundland." From these figures it appears that 2,000 miles of cable made and laid cost 775,000*l.*, at the same price 3,000 miles of cable of the same quality in all respects will cost 1,162,500*l.*, and two cables of that length will cost 2,325,000*l.* Now the capital of the French Cable Company is 2,080,000*l.*, which both "Scrutator" and Mr. R. Lorimer think to be too much by half a million sterling. Perhaps these gentlemen think that the French Company should lay an *inferior* cable costing less money. No doubt such a suicidal policy on the part of the French Cable Company would be agreeable to the shareholders of the present Atlantic Cable Companies.

If the French Company can lay two cables of 3,000 miles each for the amount of their capital, they will be the cheapest cables laid across the Atlantic, length for length, by 245,000*l.*

In the second place, Mr. Lorimer asks, "if the French Company has obtained the consent of the holders of the existing Congress rights" to land its cables on the shores of the United States. I beg to say that there are no existing Congress rights held by any one whose consent is necessary to be obtained.

I enclose a copy of the Act, and refer you to the "Statutes at Large" of the United States, which you will find at the Embassy and Consulate of the United States.

As incontrovertible evidence of the fact that no exclusive privilege was granted by that Act, the first French cable was laid to the shores of the United States in 1869 by permission of the Government of the United States, and, surely, if any such exclusive privilege had been granted, the Government could not and would not have permitted such a violation of its own law.

President Grant in his "annual message" to Congress in December, 1875, informed that body that he had refused to allow that cable to be landed on the shores of the United States until the *exclusive* right granted to the French Company should be abandoned. He said the policy of the Government was to encourage the laying of cables, and that he would permit any cable to be landed, provided no exclusive right was given to it, and provided further that by the terms of the grant under which cables should be laid, no amalgamation or combination with other cables could be had. This message of President Grant can be found also at the Embassy or Consulate of the United States.

In the third interrogatory Mr. Lorimer asks whether the French Company have made arrangements for getting messages transmitted over any portion of the land lines of the United States, as the corporations who own these lines "have already other interests to serve?"

The answer to this is the answer given by Mr. Wm. Orton, President of the Western Union Telegraph Company (which owns more miles of lines than any Government), to the meeting of the Anglo-American Company in December, 1869, or January, 1870.

Mr. Orton was asked whether the contract made by his company with the Anglo-American Company—by which the former was bound not to act for any other Atlantic Cable Company—was to be enforced, and his reply was:—

"That contract must be rescinded. Neither the laws nor public opinion of the United States will permit my company to carry it out. We are common carriers, and must treat all alike."

The report of this meeting of the Anglo-American Company will be found in *The Times* of that period.

In regard to the tariff said to be proposed by the French Company, that is a matter for the judgment of the directors, and I forbear to make any remarks thereon, as I desire to confine myself to facts only, for which I offer indisputable evidence.—Yours truly,

INQUIRER.

London, Jan. 27, 1879.

(Act of Congress, March 29, 1867.)

"Be it enacted that the American Atlantic Cable Company of New York be and are hereby vested with the right, power, and privilege, having acquired the necessary land therefor, to lay, land, and operate their cable or cables on the Atlantic Coast, except on the coast of Florida, within the jurisdiction of the United States; and the right, power, and privilege so to lay, land, and operate their cable or cables shall be vested in the said Atlantic Telegraph Company for the period of twenty years from the approval of this Act, provided that said Company shall commence active operations within the space of two years from the approval of this Act."

"A SIMPLE ELECTRIC PEN."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been directed to the letters on the above subject, signed respectively, "M. S. F. E.," "S. Garratt," and "A. Pumphry." I am glad to see that the first-mentioned correspondent has understood, and approves of the contrivance in question, and I thank him for the kind way in which he has expressed that approval; the value of his testimony, however, would have been materially enhanced by the addition of his name.

Mr. Garratt's letter is interesting as being evidence—certainly of an absolutely unbiassed kind—in support of the really practical nature of my Electric Pen, which I may here observe was first devised by *me*, and tried by one or two friends about the third week in last June. Other things intervening, notably the researches culminating in my "Electro-calcic Light," it was quite late in the year before I remembered a promise made some months before to a friend to publish the "Pen" *pro bono*.

Mr. Pumphry's friendly criticism bears within itself a sufficient refutation to his implied argument. He has evidently made his experiments and drawn his conclusions alike too hastily, the former with too much "point," the latter with too little. Everyone will readily admit that *with an unguarded electrode "point," or "wire,"* the "spark" *will* "deviate to the right and left of the true line;" in fact, the insulated stylus described in my former communication was expressly designed to remove

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this ve y obvious defect, or, in other words, to guide and direct the naturally erratic spark; for this purpose it is of course essential that the insulating tube in which the "point" is concealed should *not* be longer than is absolutely necessary. The character of the spark itself may, of course, be modified, and will by various means, especially if the weight of the stylus be slightly increased, as by enlarging the wire near the "sparking point" into cylindro-corroidal form of about half the diameter of a "*Minié bullet*," or by forming the "pen," by winding several yards of insulated copper wire round a slender bundle of fine iron wire, insulating the whole as before in an ivory tube, in which one rod of the copper wire is connected to the terminal at the top, and the other with the adjustible platinum point.

As regards the statement that the sparks are not as continuous, by which is probably meant *rapid*, as they should be, I can only say that any degree of rapidity required can be imparted, this depending chiefly upon the form of contact-breaker employed. I have successfully used several forms, but I need not trespass upon your space to describe these sufficiently-obvious points of detail to your ingenious readers.—Yours, &c.,

Widlington, Jan. 22, 1879. W. LASCELLES SCOTT.

ELECTRO-MAGNETIC AND MAGNETO-ELECTRIC INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly allow space for the following letter, in order to bring before your readers a question which is of practical as well as theoretical importance.

Dynamo-electric machines and electro-magnetic machines fall under the same law of action, viz., that inducing and induced currents are produced reciprocally between the conducting wire and the magnets, and *vice versâ*.

The question, therefore, arises, which is the best mode of multiplying these effects?

Some forty years ago my attention was necessarily directed to this problem, and my interest in it has recently been revived in connection with the theory of dynamo-electric machines.

From the first galvanometer to the largest electro-magnet ever produced, we have always multiplied the effects by simply adding to the number of turns of wire in a coil, through which the current had to pass. In the electro-magnet the iron core was supposed to become efficient in proportion to the multiplied windings of wire. But can the maximum magnetisation be produced by this means? Has not the coercitive force of the magnets as hitherto employed impeded the production of the maximum effect; and can we not produce stronger magnetism by a given current, or a stronger induced current in the wire, by a given magnetism in the case of dynamo-electric machine?

Many experiments have convinced me that complete multiplication cannot be, unless there is multiplication of the electro-magnets, and the time has arrived for the solution of this problem, on which is dependent in very great measure the compactness and power of machines for producing electric light.

I am, therefore, constructing a machine (which I hope shortly to describe to your readers) in which I cause every portion of the surface of the wire to produce the maximum of separated magnetism by means of a large number of little magnets, which surround the wire in close proximity. This combination of multitudes of small magnets is devised so that all the iron poles act closely on each other and simultaneously on the insulated wires, and *vice versâ*.

It is possible, however, that some of your readers may be able to further work out this idea, and carry the principle into effect in a more perfect manner; and, in the interest of progress, I should be glad that this should be done by the endeavours of others, if not by my own.—Yours, &c.,

J. L. PULVERMACHER.

THE DE MERITENS MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can any of your correspondents help me with information concerning the De Méritens Electric Machine?

I have been studying the diagrams in your valuable journal, but cannot understand:—

1st. In what way (whether all in the *same* direction, or *alternate*) the insulated wires are wound on the cores of the armature.

2nd. What is done with the ends of these wires (there being, as stated, neither commutator nor collector).

3rd. How the current, evidently induced in the various helices and cores of the revolving armature, gets conveyed to the frame work supporting the magnets, so as to be taken from the terminals there shown in diagrams.

4th. By virtue of what arrangement *one* of these terminals is + and the other — (both of them seeming to be in electrical connection).

If any of my fellow readers of *The Electrician* can help me out of my difficulties, they will much oblige, Yours, &c.,

A PUZZLED AMATEUR.

Castle-road, Southsea, 28th January, 1879.

THE MICROPHONE AND THE ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have long had a fancy that the electric arc would act microphonically; and the point now in dispute between Mr. Varley and Professor Hughes suggests the advisability of testing the idea for the purpose of determining the true physical action of the microphone. With *fixed* carbons, a steady light (obtained by battery power), and a suitably constructed telephone in the circuit, I apprehend that words spoken near the arc would be reproduced in the telephone. Will anybody try it?—Yours, &c.,

Jan. 27, 1879. J. L.

ELECTRO-PHYSIOLOGY.

Abstract of a paper read before the Royal Society, "On the Effect of Strong Induction-Currents upon the Structure of the Spinal Cord," by William Miller Ord., M.D., F.L.S.:—

"The results of a series of experiments are related. They were founded upon considerations offered by chorea, tetanus, and similar diseases; certain clinical facts and post-mortem obvervations having led the author to suppose that the occurrence of protoplasmic convulsion or spasm in the grey matter of the nervous system was consistent with the morbid appearances and with the history of cases.

"The present series of observations was made upon adolescent dogs. The spinal cord was the part selected for experiment. The dogs were killed by chloroform, and the cord, rapidly exposed, was galvanised for different periods and in different directions. In all cases parallel experiments were made with dogs of the same age and size, all points of the operation being carried out in the same way, save for the application of the galvanic currents.

"The following effects were observed:—1. Broadening of the cord in parts through which currents had been passed longitudinally, narrowing where transverse currents had been applied. 2. In the narrowed parts a great diminution in the sectional area of the grey matter with retraction of the posterior horns. 3. In the same parts a remarkable dilatation of the central spinal canal, and an infiltration of myelin and leucocytes into the cavity. 4. The production of spaces around corpuscles, vessels, and nerve-bundles by the retraction of the protoplasmic matter. Such spaces were often found filled with *débris*, containing coagula, myelin, and vacuoles. They corresponded in appearance with the 'perivascular erosions' of Dickinson. 5. The contraction of nerve-corpuscles, which, being much more marked between their branches, gave them a scalloped appearance. Vacuoles were formed within them, and in the spaces formed by their retraction, and by the retraction of surrounding parts. 6. In some places rupture of nervous tissue was observed. 7. In longitudinal sections nerve-fibres were found flattened and varicose, the flattening resembling that described by Elischer in fibres of median nerve in chorea.

"*Conclusions.*—1. That, in young dogs, the protoplasmic constituent of the grey matter contracts *en masse* under the influence of strong faradaic currents. 2. That it contracts unequally and irregularly by reason of its unequal and irregular sectional area, causing thereby condensations at certain points—notably in the anterior horns and around the central canal—and rarefaction at others—notably in the middle of each crescent; such rarefaction going on sometimes to rupture of tissues. 3. That nerve-corpuscles contract in various degrees according to the strength and duration of currents, and that while they tend in contraction to become spherical they also tend to become vacuolated. 4. That the vessels are in some places strongly contracted and empty; in others dilated and filled with blood clot, having the appearance of embolus. 5. That the appearances correspond so decidedly with appearances in chorea and tetanus as to give ground for the supposition that contractions, such as are produced by electricity, do actually occur during life under the effect of nervous shock, and may be phenomena causal or associate of disease."

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ON THE EXCITATION OF ELECTRICITY AT THE CONTACT OF SOLIDS AND GASES.

BY W. BEETZ.*

When publishing my first experiments on the electromotive forces of gas batteries, I expressed my ideas respecting the place at which the seat of the difference of tension produced was to be sought.† Grove had assumed that it was the place of contact of the platinum, gas, and liquid.‡ I did not admit the universal correctness of that assumption: it is certainly not true for gases which, like chlorine, strongly absorb water; for a platinum plate entirely immersed in a liquid containing chlorine behaves, in respect of its electricity, very differently from a plate of platinum immersed in a liquid free from chlorine. I showed that what happens with other gases may be regarded as precisely similar; only it is the less distinctly manifested the less soluble they are in the liquid. The upper part of a platinum plate, enveloped in hydrogen, I covered with an insulating layer, so that the free platinum was entirely covered by the liquid, and yet it preserved a real gaseous element, certainly of somewhat less electromotive force than if the upper end of the platinum had been directly surrounded by the gas. I have in the place above cited given my views respecting the reasons for this difference. Gaugain subsequently arrived at the conclusion that the platinum acts only upon the gases dissolved in the liquid.§ A platinum wire surrounded by the gas and dipping in the liquid he gradually lowered until it was all covered by the latter; he then obtained precisely the same difference of tension as when one part of the wire was surrounded by the gas and the other by the liquid. This result I accounted for by remarking that, in making the experiment thus, the wire had at first been actually in contact with the gas, and then carried a condensed layer of gas with it into the liquid.‖ I have further, in the above-mentioned treatises, stated my views upon the following:—that the amount of the difference of tension between a clean metal and one coated with a gas depends on the degree of such condensation of the gases; that the condensation is greater or less, according to the metal with which the gas elements have been produced; and that a singularly high degree of condensation is produced by electrolytic polarization, on account of which the electromotive force of the gases is in this case peculiarly great. The considerable difference of tension produced by the action of even small quantities of hydrogen on platinum I compared to the analogous phenomenon shown by the position of the amalgams in the tension series. Macaluso has moreover pointed out that far greater electromotive forces can be generated by the long-continued electrolytic evolution of hydrogen, or chlorine, or at platinum or carbon electrodes than by simple contact of the gases with the plates or by gas being evolved at them during a short time; he therefore believed that an active state must be ascribed to the gases separated by electrolysis, similar to that which is known to us in oxygen.¶ In truth, as regards hydrogen, the presence of an active modification, previously assumed by Osann, has been rendered very doubtful by Magnus**.

While the subject of all the above investigations was the presence of considerable quantities of gas on the metal plates, there has recently been a discussion in detail of the case in which only thin films of gas have formed upon the plates. F. Kohlrausch has subjected these films to a careful consideration;†† and Helmholtz‡‡ and Herwig§§ have made the analogy between a layer connecting two polarised electrodes and a condenser the subject of their investigations. Herein Helmholtz has advocated the view that in the polarization not merely portions of gas adhering to the surface, but also portions which have penetrated deeper into the platinum must play a part—the possibility of which had been already indicated by Graham's experiments on palladium and platinum. In fact, Crova,‖‖ and after him Root also,¶¶ succeeded in proving that, with the electrolysis of dilute sulphuric acid, hydrogen penetrates through a platinum plate, since the plate not only exhibited polarization on the side where the electrolysis took place, but was protected on the opposite side from all electrolytic action.

But few investigators, in studying galvanic polarization, have taken into consideration other gases than hydrogen and oxygen; hence the question arises whether the views which hold good for these two gases, and preferably for hydrogen, can be extended in their entirety to all cases of polarization. A series of experiments which I have made with palladium and carbon electrodes may contribute to the answering of this question.

To procure exact knowledge respecting the electromotive position of palladium is a very difficult task. Palladium as obtained in commerce has always been heated to incandescence, and has taken in gases in the process, as Graham has shown. The means usually employed to expel such occluded gases, especially hydrogen, from the palladium are so far sufficient that chemical analysis can show no traces remaining, but do not suffice to destroy all change in the electromotive state of the metal. This is especially true of the treatment with the mercury air-pump; I have never been able in this way to bring back a palladium plate quite to its previous electromotive position after evolution of hydrogen had taken place on it. On the other hand, the last trace of hydrogen can be completely removed by a long-continued evolution of oxygen. But then the plate becomes covered with a coat of brown oxide; and if this be ever so carefully rubbed off, yet the plate always takes a much more negative position in the tension series than if it had been cleaned with hydrochloric acid. For the determination of that position I made use of my universal compensator*, with which also all the other measurements of the differences of tension we shall have to consider were made. The palladium plate to be tried dipped into very dilute sulphuric acid (1 : 100), and thus formed the negative constituent of an element, of which the positive consisted of an amalgamated zinc cylinder standing in a concentrated solution of sulphate of zinc. The two fluids were connected with one another by means of a syphon filled with dilute sulphuric acid and closed at both ends by clay cells. A Daniell element in the form previously employed by me served as unit, its zinc-cell being filled with solution of sulphate of zinc. If d denote electromotive force of such an element, and D that of a Daniell element the zinc-cell of which contains dilute sulphuric acid, then $d = 0{\cdot}95\ D$. As the force D is generally taken for the unit force, I have reduced all the following data to the same. In like manner I cite from previous memoirs the values of the electromotive forces in terms of the unit $D = 1$. I also regard always as the point of issue, *i. e.*, the positive part of the element in question, the amalgamated zinc in dilute sulphuric acid; so that, for example, the electromotive force of zinc in dilute sulphuric acid | Platinum in dilute sulphuric acid (or, abbreviated, Zn | Pt) = 1·61 D; Zinc in dilute sulphuric acid | Platinum coated with hydrogen in dilute sulphuric acid (or Zn | Pt, H) = 0·80 D, &c. Thus I found the force Zn | Pd, when I had only mechanically rubbed the oxidized plate, always very great, varying between 1·90 and 2·03 D, evidently because there were always some remains of oxide still adhering. But if the brown oxide was removed by diluted hydrochloric acid, the electromotive force was found to be constant within tolerably narrow limits—namely,

1·24, 1·26, 1·24, 1·29, 1·32, 1·31, 1·28.
Mean ... Zn | Pd = 1·28 D.

If we may regard as actually pure the palladium thus cleaned, its position in the electromotive series is considerably nearer to zinc than that of platinum. Still, it is not advisable, in measuring experiments, to refer the position of a palladium plate polarised by any gas to that of pure palladium; it can be much more certainly ascertained if, under all circumstances, the amalgamated zinc plate in a concentrated solution of sulphate of zinc be united with the plate to be examined by the syphon to form a series, or if two plates polarized by different gases be placed immediately opposite one another.

Two strips cut from the same sheet of palladium were passed through corks, which closed the upper ends of two glass tubes. The tubes were filled with diluted sulphuric acid and plunged upside down into a glass containing the same fluid. Oxygen was then introduced into one of the tubes and hydrogen into the other. Both the gases had been evolved by electrolysis and kept in small gasometers, from which they could be taken as required.

The plate enveloped in oxygen exhibited not the slightest alteration in its electromotive quality, neither immediately nor after a longer-continued action of the oxygen. The difference of tension Zn | Pd, O was invariably the same as Zn | Pd. The hydrogen gas, on the contrary, exerted a powerful influence from the first moment onwards: at the appearance of the first gas-bubble the palladium became at once positive; and after gas had been absorbed for some time by the metal the force Zn | Pd, H

* Translated from Wiedemann's *Annalen*, 1878, No. 9, vol. v. pp. 1-20, in *Phil. Mag.*, Jan. 1879.
† Pogg. *Ann.* vol. lxxvii. p. 505.
‡ Phil. Trans. 1813, pt. 2, p. 97.
§ *Comptes Rendus*, t. lxiv. p. 364 (1867).
‖ Pogg. *Ann.* vol. cxxxii. p. 461.
¶ *Ber. d. k. sächs. Ges. d. Wiss., math-phys. Cl.* 1873, p. 306.
** *Conf.* Wiedemann, *Galvanismus*, 2nd ed. vol. i. p. 533.
†† *Gött. Nachr.* 1872, No. 23, p. 453.
‡‡ *Monatsb. d. Berl. Akad. d. Wiss.* 1873, p. 587.
§§ Wied. *Ann.* ii. p. 566.
‖‖ *Mondes T. V.* p. 210 (1864); Wied. *Galv.* (2) i. § 498.
¶¶ *Monatsber. d. Berl. Akad. d. Wiss.* 1876, p. 217.

* Wied. *Ann.* iii. p. 1.

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was found, in different experiments made with plates or wires, to be

0·64, 0·69, 0·71, 0·70, 0·69.

Mean ... Zn | Pd, H = 0·69 D.

At this height it remained even when hydrogen had been introduced from without (or evolved on the plate itself) so long that the palladium could absorb no more, but free hydrogen enveloped its upper surface. According to this, the tension-difference would be

Pd, H | Pd = 1·28 − 0·69 = 0·59 D,

while I had previously found

Pt, H | Pt = 0·81 D.

Whether the palladium was employed bright, or coated with palladium-black, made no difference.

Further, palladium plates were used as the electrodes of a Grove's pile of three or four couples, or a Meidinger's pile of six couples. These electrodes were also enclosed in glass tubes, to enable me to continue the electrolysis until the hydrogen was no longer absorbed by the palladium. The measurement of the polarization present was, as before, effected by means of the universal compensator. With some practice the simple discharge obtained at it furnished very constant results, even though, like all similar contrivances, it was not entirely free from the inconvenience that the polarization-current was not closed till some, although a very short, time after the interruption of the polarizing current. To distinguish it from the electromotive force Zn | Pd, H, which was excited by merely enveloping a palladium plate in hydrogen, I denote by Zn | Pd_H the force excited by the galvanic polarization of hydrogen. This was found to be

0·69, 0·71, 0·67,

Mean ... Zn | Pd_H = 0·69 D,—

that is, exactly equal to Zn | Pd, H. In this case, therefore, no more hydrogen could be pressed into the palladium plate; the plate was already saturated with hydrogen.

(TO BE CONTINUED.)

ELECTRIC LIGHTING.

Report presented by M. Cernesson, in the name of the Third Commission of the Municipal Council of Paris* :—

"GENTLEMEN: In a memorandum of the 26th November last M. the Prefect of the Seine submitted to the Council a proposal from the Compagnie Générale d'Electricité, in which this company applies for the concession, during a period of three years, of the lighting of a number of streets and public places by means of the processes of electric lighting by the Jablochkoff system.

"We have already in a preceding report, dated 30th Nov. last, briefly made known to you the bases of the propositions made by the Compagnie Générale d'Electricité. Consequently, upon the reading of this report you authorised, as a strictly provisional measure, the continuation of the trials of electric lighting at all the points where it had been established in virtue of your previous decisions up to the 15th January, in order to allow your Third Commission the time necessary for the study it proposed to make of public lighting in general.

"In order to carry out this study your Commission had, in the first place, at its disposal the very detailed reports of MM. Th. Lévy, ordinary engineer of the first section of the municipal service; Allard and de Fontanges, chief engineers, and F. Leblanc, gas inspector; reports which were annexed to the memorandum of M. le Préfet. However detailed these reports may be, they did not appear to us sufficient in view which we proposed to accomplish, and we desired to complete the various information already supplied by successively calling upon the commission, MM. the town engineer, MM. the representatives of the Compagnie Génerale d'Electricité, and those of the gas company.

"All these gentlemen replied most willingly to our appeal and to all the questions which were addressed to them. All the information thus collected constitutes the foundation of the work which we have the honour to lay before you. This work comprises three portions; the first contains an examination of all the questions relating to electric lighting, such as the description of the appliances, the mode of working, &c.; the second contains comparative indications of the illuminating powers or the relative intensities of the electric light and gas light; and, lastly, the third sums up the observed facts in such manner as to deduce from them conclusions of the nature required by the propositions which your commission thought necessary to put forward.

"I.—*Indication of the process of electric lighting and of its mode of working.*—Every establishment for illumination by means of the electric light, according to the Jablochkoff system, necessitates:—

'1. A motive power for the purpose of producing a very rapid movement of rotation in magneto-electric* machines;

'2. A magneto-electric machine, or a series of magneto-electric machines;

'3. A certain extent of conducting wires, intended to transmit the magneto-electric currents from the machine to the points where the centres of light are established;

'4. One or more centres of light.

"*Motive Power.*—The motive power intended to work the magneto-electric machines should generally give 20 horse-power for every 16 centres of light, *i.e.*, 1¼ horse-power for each light.

"The directors of the Compagnie d'Electricité are in hopes of very considerably reducing the motive power required; recent experiments allow them to state that this may be reduced to 1 horse-power for every 3 centres of light. Under these circumstances, an ordinary gas engine, termed the Lenoir machine, which gives 4 horse-power, could produce 12 lights; but as yet we cannot count upon this reduction in the motive power, nor, consequently, upon the cost price, viz., about 55 cent. per horse-power per hour; or, for each light, about 0·55 × 1·25 = 0f. 69c. per hour.

"*Magneto-electric Machines.*—These machines originate, by means of induction, the electric currents which are conveyed to the centres of light. The machines actually employed at the Avenue de l'Opéra are those of Gramme, constructed with an annular electro-magnet, which transmits its condensed currents to a second magneto-electric machine termed the *machine for light*. The number of revolutions in the Gramme machines is 600 per minute, and the currents successively transmitted by means of eight coils arranged in the most suitable manner for the purpose is 8 × 600 = 4,800 in each direction per minute.

"*Conductors.*—The conductors are intended to convey the condensed currents from the magneto-electric machines, and to distribute them to different centres of light established at various points, and distributed according to the requirements of the illumination to be provided.

"They consist of a cable formed of seven brass† wires, imbedded in a composition of gutta-percha, then covered with india rubber, and in addition, with a waterproof fabric. The conductors thus made up are sheltered from water and moisture in a kind of sheath or conduit, that is to say in drain pipes perfectly connected together by cement.

"*Centres of Light.*—The electric centres of light are composed of one or more *bougies* of the Jablochkoff system.

"Each *bougie* or candle is composed of two small rods of carbon placed in juxtaposition to an intermediate plate formed of a composition of plaster and sulphate of baryta.

"By means of an armature placed at the base of the *bougie*, and specially arranged with a view to this effect, the positive and negative currents from the electro-magnets arrive at the points of the carbons and give rise to the luminous voltaic arc between the latter. A focus of light is thus obtained, which lasts until the *bougie* is consumed, provided always that no interruption occurs in the transmission of the currents.

"Such an interruption might occur from various causes, notably, in consequence of an accident happening either to the engine which supplies the motive power, or to that which furnishes the light, or else simply by a defective action of the *commutators*‡, or, lastly, by a simple breakdown of the conductors.

"When this interruption occurs, there is either partial or total extinction of the light, according as the transmission of the currents is arrested in relation to one *bougie*, or to a portion only of the *bougies*, or in relation to all the *bougies* contributing to the illumination.

"There is at the present moment no means of obtaining a complete guarantee against all the causes of extinction. The Compagnie Générale d'Electricité hopes that with time and experience it may succeed in affording such a guarantee; since it should in justice be said, it has succeeded in diminishing more and more the chances of interruption. But in point of fact it must be admitted that we cannot count upon an absolute regularity of working in the electric light."

(TO BE CONTINUED.)

* Translated from the *Revue Industrielle*.

* In the original, the word "electro-magnetic" is substituted throughout for "magneto-electric."—ED. *E.*

† This, we have no doubt, is an error, since it is well-known that copper is the only suitable conductor in this case.—ED. *E.*

‡ The commutator is an appliance the object of which is to cause the alternate currents to pass successively to each of the *bougies* at a given luminous centre. Since a *bougie* has a mean duration of only one hour and forty minutes, the commutator is arranged so that it can light a second *bougie* when the first is consumed. Thus, with four of the candles, the light from a given point may be made to last for nearly seven hours, without the intervention of a workman.

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ELECTRICAL POTENTIAL.

BY M. DU MONCEL.

Writing to our contemporary, *l'Electricité*, the able author of the "Exposé des applications de l'Electricité" replies as follows to certain strictures upon the use of the term *potential*:—

"I take this opportunity of drawing your attention to the fact that the anathema pronounced against the term *potential*, which has been introduced in modern science, is quite uncalled for. It is one which is indispensable to those concerned in exact science, and can be criticised only by those who are unacquainted with the accurate definition of the term in question. I think it advisable, therefore, to send you some observations on this subject, in order that its importance may be duly appreciated.

"It is generally supposed that *electrical potential* is merely another expression for *electrical tension*; and the question arises why the latter term, which ordinarily conveys a satisfactory idea to the mind, should be superseded? But it is only necessary to define these two expressions in order that their difference should be perceived.

"The *tension* of a current is that property of the electric fluid which gives, so to speak, the impulsion to the electrical movement, and which is exhibited externally by a tendency to react upon neighbouring bodies, and to produce the effects which belong to statical electricity. It is the quantity of electricity maintained in a free condition when the poles of the battery are disconnected, and which escapes recomposition during the period in which the production of electricity takes place.

"The *potential* of an electrical source depends, it is true, upon the tension; but being connected with the electrical actions themselves, it can represent tension under conditions which are better determined, and capable of being reduced to calculation. It may be roughly defined by saying that *it is to electricity what temperature is to heat*. It is, so to speak, the quality of the electricity, and this property has no relation to quantity. The notion of the potential of an electrified conductor naturally arose in the study which was necessary of the conditions of electrical equilibrium according to the laws discovered by Coulomb. In order that these conditions of equilibrium should exist the resultant of the attractive and repulsive forces exterted an interior point must be *nil*; but it does not follow on this account that the action of electrical masses distributed on the surface of the conductor should equally be so; and it is the analytical expression which represents this action with this resistance of *nil* which has been termed the *electrical potential*, or, rather, the *potential function*. It is written thus: $-\Sigma\frac{m}{r}$, and it is constant when the conditions of equilibrium have been established in the sense that has been defined above.

"In order to obtain a material idea of potential, the distribution of electricity amongst various conductors is sometimes compared to the distribution of a fluid in a system of vessels, placed in communication with each other. The initial potential of each conductor represents the initial level of each reservoir; whilst the quantity of electricity represents the quantity of liquid. This constant quantity becomes divided, so that the final level should be the same in the two vessels; then the potential becomes the same in the two vessels, and we may say that the electrical equilibrium of a system of electrified conductors brought into communication with each other is obtained by the equalisation of the potential.

"M. Abria, in an interesting memoir on the elementary theory of potential, defines it by stating that the potential of an electrified body is the indication of a torsion balance, in which the moveable and fixed balls are two small equal spheres which, whilst in contact, have been placed in connection with the body by means of a long, fine wire.

"These various considerations suffice to show the importance of this element of calculation in the mathematical researches on electricity, which, whatever the author of the article to which I allude may say, have caused a considerable advance in electrical science and its applications.

"We should like to know whether submarine telegraphy would have arrived at its present position without mathematics; and certainly all the beautiful laws of electrical propagation, which form the basis on which all telegraph lines are established, would have been long ago ignored if we had not had as a guide the admirable mathematical theory of Ohm, which preceded by ten years the researches of Pouillet, whatever may have been said to the contrary.

"If practical men were more mathematical, and theoretical men a little more practical, science would make much more rapid progress."

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED). The total earnings of this Company for the year ending September 30 last were 92,882*l.*

ELECTRICITY AS A SOURCE OF LIGHT.*

BY PROFESSOR REDWOOD.

Thirty years ago I lectured in this institution on "Electricity as a Source of Light." The subject was then occupying public attention in very much the same way as it is now. It was known that by means of electricity a brilliant light could be produced, which Sir Humphrey Davy and Faraday had publicly demonstrated, and which the improvements effected in galvanic batteries by Daniel, Grove, and Bunsen, had rendered comparatively easy of attainment.

The dazzling spark between charcoal points, and the more subdued light of incandescent platinum, were familiar illustrations at the lecture table, and such effects, so easily produced by dissolving a few bits of metal in acid, could hardly have failed to draw attention to this wonderful agent, electricity, as a source from which a light of great intensity and purity could be obtained, which it was hoped might be made available for many if not most of the purposes for which artificial light is required.

Numerous improvements had previously been made in the systems of artificial lighting. We had progressed from rush lights to snuffed lights, from dips to moulds, from fats to fatty acids, and then from all these and many forms of improved lamps, a great stride had been made in the discovery of gas lighting.

But still we had not quite attained to perfection. The light was imperfect, and the effects of all these systems of lighting were in one way or another objectionable. There was too much heat with the light. Then the vital element of the atmosphere was consumed in producing the light, and poisonous gases were substituted, including sulphur acids which corroded and destroyed the goods in our shops and the furniture of our houses. In these respects there was ample room for improvement, and this it was hoped was attainable through the agency of electricity.

Science had been making rapid strides, and especially the department of it which includes electricity. Galvanic electricity, although comparatively a modern discovery, had been developed with amazing rapidity, and the results of the researches of Faraday and others had then attained to the zenith of their fame.

This kind of electricity, the electricity of the galvanic battery, which is distinguished as current or dynamic electricity, is the only sort of electricity available for the production of a continuous light. It may, however, be produced by other means than that of a galvanic battery. Its distinguishing features are, the continuity of its discharge, the largeness of the quantity of the force that can be practically produced, and the comparative lowness or feebleness of the intensity of the force.

The continuity of the discharge gives it the character of a current, and serves to distinguish it from frictional or machine electricity, which is called statical electricity or electricity in equilibrium, just as a current of water is distinguished from a suspended drop of water, the latter being in equilibrium until by a single impulse it falls and is discharged.

The largeness of the quantity of the force that may be thus produced also serves to distinguish it from frictional electricity, the quantity of which, as produced by any practical method, is infinitely small as compared with the electricity of the battery.

And lastly the comparative lowness or feebleness of the intensity of the force forms an important distinguishing feature in this kind of electricity, as evidenced by the fact that the electricity of a powerful battery will not pass through a space the two-thousandth part of an inch in length if filled with a non-conducting medium such as air, when the electrodes or poles are metallic.

Now all these qualities which are possessed by dynamical electricity contribute to adapt it for the purpose of electric lighting. We want a continuous current of a large quantity of electricity of comparatively low intensity.

The galvanic battery supplies this want, but it demands rather a high price for it, not only in regard to the materials consumed, but also in regard to the labour and risk of accident involved in keeping up the motive power.

The source from which this power is derived is practically the same as that from which the light of a candle or lamp, whether of oil or gas, is derived. In either case the force originates in chemical action. In one case we are burning up the metal zinc, and in the other we are burning the carbon and hydrogen of the combustible substance used. There is this difference between the two cases, however, that in the case of ordinary combustion for the production of light, the power developed by the chemical action which occurs is instantly and locally expended in the pro-

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* Substance of a lecture delivered before the Pharmaceutical Society of Great Britain, Wednesday, January 8, 1879.—(From the Journal of the Society.)

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duction of the new force—the light which results—that is to say, the effects are all produced in one and the same place; whereas, in producing light by electricity, the development of the new force may be transferred to, and applied at, a considerable distance from the point at which the chemical action occurs.

This is clearly so with reference to the galvanic battery, by means of which electric lighting was originally effected, and we shall see presently that it is so also with reference to the more modern method of producing currents of electricity for a similar purpose, in which we substitute the combustion of coals for that of zinc, and the application of steam power for battery power.

Among the early difficulties experienced in making electricity available as a source of light, the cost of battery power no doubt occupied a prominent position, but it was known then as it is now, that current electricity could be produced without employing galvanic batteries. Magneto-electric machines had been constructed forty years ago, and the principle of their action was well understood. I have one here that was in my possession more than thirty years ago, and although this Saxton's machine is little more than a toy when compared with those now constructed, yet it is capable of producing the electric light on a small scale without the expenditure of any other force than that which is required for mechanically rotating the armature of a magnet in front of the poles of the magnet.

Faraday, about the year 1831, had shown that if a conductor of electricity is moved so as to cut the lines of magnetic force of a magnet, a current of electricity will pass through the conductor. This is the fundamental principle, or at least one, and the most important, principle involved in the construction of these machines. In 1832 Pixii made the first practical application of the principle in the construction of a magneto-electric machine, which was improved by Saxton in 1833, and here we have Saxton's machine, which was subsequently improved by Clarke in 1836. Since then we have had many other improvements.

Now those were revolutionary days, and the great dynamo-electrical revolution had then commenced which has since resulted in the development of the system now so effectively applied for the production of artificial light by electricity.

Thirty years ago, in discussing the subject of electric lighting we were speculating as to the practicability of improving galvanic batteries for the cheaper production of electricity, but nothing has since been done in that direction. We have no better batteries now than those we were then using for this purpose, and we have ceased to look to galvanic batteries for the large supply of electricity required for the electric light.

(TO BE CONTINUED.)

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Jan. 29.		Business Done Week Ending Jan. 29. Highest.		Lowest.	
Anglo-American	58¼,	59	58¾		58¼	
Do. "B"	84¼,	¾	84¾		84¼	
Do. "A"	33¼,	½	33¾		33¼	
Brazilian	6¾,	⅞	6 11-16		6¾	
Cuba	8¼,	9½	—		—	
Do. Ten per Cent. Preference	15¼,	½	—		—	
Direct Spanish	1½,	2	—		—	
Do. Ten per Cent. Preference	9½,	10½	10½		10½	
Direct United States	11¼,	½	11½		11¼	
Eastern	7 3-16, 5-16		7⅜		7⅛	
Do. Six per Cent. Debenture	104,	107	—		—	
Do. Five per Cent. do.	102,	105	104		103	
Do. Six per Cent. Preference	11,	¼	11⅛		11⅛	
Eastern Extension	7 1-16, 3-16		7⅛		7⅛	
Do. Six per Cent. Debenture	107,	109	109½		108½	
German Union	7⅞,	8⅛	8		8	
Globe Telegraph and Trust	5,	¼	5¼		5	
Do. Six per Cent. Preference	10½,	¼	10½		10⅜	
Great Northern	7¼,	8¼	—		—	
Indo-European	19,	20	—		—	
Mediterranean Extension	2¼,	3¼	3 1-16		3	
Do. Eight per Cent. Preference	9,	¼	—		—	
Reuter's	10,	11	—		—	
Submarine	217,	222	222		222	
West India and Panama	1½,	2½	2 1-16		1 15-16	
Do. Six per Cent. Preference	8¼,	½	8¼		8¼	
Western and Brazilian	2¼,	⅜	2⅜		2⅜	
West. Union Seven per Cent. 1st Mort.	114,	118	117⅜		117	
Do. Six per Cent. Sterling	101,	103	—		—	

TRAFFIC RECEIPTS FOR DECEMBER, 1878.

Companies.	Dec. 1878.	Dec. 1877.	Incrse.	Decrse.
Anglo-American Telegraph Company	47,040	45,570	1,470	—
Brazilian Submarine Company	14,231	12,318	1,913	—
Cuba Submarine Company	2,800	2,666	134	—
Direct Spanish Telegraph Company	939	857	82	—
Direct United States Telegraph Company	13,970 estd.	12,930	1,040	—
Eastern Extension Telegraph Company	22,929	23,980	—	1,051
Eastern Telegraph Company	38,467	37,777	690	—
Great Northern Telegraph Company	14,803	—	—	—
Submarine Telegraph Company	8,498	8,754	—	256
West Coast of America Telegraph Company	2,260	1,860	400	—
West India and Panama Telegraph Company	5,304 estd.	4,558	746	—

THE EASTERN TELEGRAPH COMPANY (LIMITED).

The Thirteenth Half-yearly Ordinary General Meeting of the Shareholders of the above Company was held on Thursday last, at the City Terminus Hotel, Cannon-street, under the presidency of Mr. John Pender, M.P., the Chairman of the Company.

Mr. George Draper (the Secretary) having read the advertisement convening the meeting, the Directors' report was taken as read. Its salient features appeared in *The Electrician* of last week.

The Chairman, in moving its adoption, said that the receipts for messages during the half year ending September last, amounted to 206,295*l.*, against 250,528*l.* in the corresponding half year of 1877, and 235,848*l.* in the previous half year—March, 1878. The revenue for the March half was always very much better than that for the September half-year. In comparing September, 1878, with September, 1877, it must be remembered that owing to the interruption of the Indo-European line for three-and-a-half months in 1877, the whole of the receipts for Indian and Trans-Indian messages belonged exclusively to the Eastern Company, a most exceptional state of things, and one not likely to occur again. About 42,000*l.* should be deducted from the amount for the half year ending September, 1877, as representing the additional revenue derived by the breakdown of the other routes before comparing it with the receipts for the past six months, and they would then have about 2,000*l.* more than they earned during the last half year. Their revenue, however, suffered to a far greater extent than 2,000*l.* by the falling off in their traffic with India and the East. They had been, and still were, passing through a season of bad trade; but when business revived there could be no doubt that the traffic would grow at least to its former dimensions, and, if they could hold their own now, the shareholders had every reason to be satisfied. A large portion of the diminished revenue from Indian messages had been made good by other sources of income which did not appear in the accounts for 1877. The return to them on the 74,000*l.* they gave for the Black Sea cable, since they took over the line on the 15th August to 31st December last, had been at the rate of 20 per cent. per annum, and their outlay in other cables in the Levant had not been unremunerative. The total expenses for the half year had been 79,220*l.*, being a decrease of 51,754*l.* as compared with the same period of 1877. The main item of decrease had been in repairs of cables, the cost for which had been 20,154*l.* as against 74,835*l.* He then spoke of the value of the telegraphic communication with India at the present moment, and said that they were most anxious to give the Press every advantage. They had proposed quarter-rates; but this was opposed by the German Government, who stood out for half-rates.

Some discussion followed, but ultimately the report was adopted, and the other business was transacted.

English Jurors at Paris, Class 65.—At the moment of going to press we are informed that Major Webber, R.E., and Mr. C. E. Spagnoletti, C.E., the former being vice-president of Class 65, and the latter supplementary juror of Group 6 (Electrical Section), at the Universal Exhibition, Paris, last year, have had the honour of being presented with a proof portrait of H.R.H. the Prince of Wales, accompanied by a gracious letter of thanks for their services from His Royal Highness as a personal mark of their connection in the work of the Paris Exhibition.

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NOTES.

THE ELECTRIC LIGHT AND THE SAN FRANCISCO GAS COMPANY.—The establishment in California of an Electric Lighting Company has had the effect of depreciating the gas shares from 110 to 70 dollars—the greatest depreciation yet recorded.

ENGLISH ELECTRICAL TEXT-BOOKS ABROAD.—The *Manual of Practical Telegraphy* of Mr. Culley has been translated into Italian by M. Cappanera, who now is translating into the same language the work on *Electricity: Its Theory, Sources, and Applications* of Mr. J. T. Sprague.

THE PARIS EXHIBITION.—We were glad to be able to record in our last issue (p. 132) that the services of the English Jurors at the Paris Exhibition, in Class 65, had been so promptly recognised. Too often the real workers are overlooked whilst others receive the praise.

OUR SPACE.—Owing to the lengthy reports of meetings we are compelled to defer several interesting papers and letters to another issue, among these are papers on "Wheatstone's Bridge," "Early Cables," &c., and letters on "Cables," "Automatic Regulation of Currents," &c.

WEATHER INDICATION.—Recent observations at the Montsouris Observatory and elsewhere, tend to show that the first symptoms of a change in the atmospheric tension, from positive to negative, after a long-continued positive tension during a frost, indicate the occurrence of a thaw.

THE BILLINGSGATE EXPERIMENT.—It is stated that the cost of the electric light during the experiments carried on in Billingsgate Market, including interest, and depreciation on plant, engine power, attendance, and carbon, was upwards of £4 per night, against rather less than £2 10s. per night for gas.

THE ELECTRIC LIGHT AT HAVRE.—The experimental trial of the electric light at the works being executed at the port of Havre has given complete satisfaction. Without waiting for the report of the committee nominated by the French Board of Works, the Chamber of Commerce has authorised the establishment of ten lights in the outer port.

VELOCITY OF ELECTRIC SIGNALLING.—According to the *Monde de la Science*, the time necessary for the transmission of an elementary signal through an overland wire, 525 miles in length, between Paris and Marseilles is ·024 second; whilst the transmission of the signal through the 574 miles of submarine wire between Marseilles and Algiers takes nearly ten times this period, or ·233 sec.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of the Cuba Submarine Telegraph Company (Limited) during the month of January was 2,682, estimated to produce £2,900; against 2,429 messages, producing £3,001, in the corresponding month of last year. The traffic receipts for the month of November, estimated at £2,600, realised £2,609.

GAS ENGINES.—In M. Cernesson's report on electric lighting, presented to the Municipal Council of Paris, it is stated that the cost of working the Lenoir gas engine is 5½d. per h.-p. per hour. From this it would appear that the engine in question is by no means the most economical of its kind, since the Otto gas engine, manufactured in this country by Messrs. Crossley Brothers, is said to consume but 22ft. of gas per h.-p. per hour, at a cost of about 1d. The Otto engine was the one used at the Royal Institution for Professor Tyndall's lecture.

MALLEABLE BRASS.—The brass alloy in most common use is probably that containing about 65 copper, 33 zinc, and 2 lead or tin. This compound works well in the lathe, and can be rolled, but is very imperfectly malleable. Recently, a brass has been manufactured which possesses entirely novel properties, and can be forged at a red heat precisely like iron, so that it becomes applicable for many purposes for which ordinary brass is unsuitable. The new alloy is composed of 57 copper, and 43 zinc; it should contain neither lead nor tin.

COST OF GAS.—It is commonly supposed that the price of gas is much higher in Paris than in London; but, according to M. Cernesson's report, it appears that the contract price paid by the Paris municipality is fifteen centimes per cubic metre, which is equivalent to about 3s. 6d. per 1,000 cubic feet. Taking the average price of gas in London as 3s. 4d. per 1,000 cubic feet, the difference of cost seems to have been overrated. It would appear also that the municipality is of opinion that they should not have to pay more than five centimes per cubic metre, although, under a contract dating from the worst days of the Empire, they have hitherto had to pay three times that sum.

ANGLO-AMERICAN TELEGRAPH COMPANY.—The report of the Anglo-American Telegraph Company shows that the total receipts for the half year were £309,570, including balance brought in of £15,120. The expenses were £55,983, and the amount of £14,146, cost of the repairing expedition, has been charged to the renewal fund. This fund has been credited with the usual £75,000, leaving a balance of £178,587 available for dividend. A distribution is now recommended of 1½ per cent., making a total of 4½ for the year, leaving £3,587 to be carried forward. The report announces that the possibility of "duplexing" the company's cables has now been placed beyond a doubt, and the system will be adopted when the rate of royalty for the patents is determined.

MAGNETICAL EXPERIMENTS IN 1667.—M. Colepress records some of his experiments to determine the difference between the magnetical properties of loadstone when hot and cold. He says: "I took an unpolished loadstone, which attracted but weakly, and heated a lath nail glowing hot, nimbly applying the north pole of the said magnet to it, which quickly took it up and held it suspended a great while. I took the same stone and cast it into the fire, letting it remain there till it was thorough hot. I applied the north pole to another lath nail cold and untouched before, which it took up but faintly, yet held it suspended for some time. Two or three days after I took the same loadstone, and found that it attracted then as strongly as before it was cast into the fire. Whence I inferred that the fire somewhat lessened its attractive faculty, but did not deprive the stone of it."

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METALLIC CHROMIUM.—M. H. Moisson has presented to the Académie des Sciences a memoir on the amalgams of chromium, manganese, iron, cobalt and manganese, and on a new means of obtaining metallic chromium. To prepare the amalgams, a protochloride of one of these metals, in solution, is treated with sodium amalgam, when chloride of sodium and an amalgam of the metal employed are obtained. By distilling the chromium amalgam in a current of hydrogen, metallic chromium is obtained. Ordinarily this metal can be produced only by means of very high temperatures and somewhat lengthy manipulations; by the new process it may be obtained in a few hours. Chromium is attacked by boiling hydrochloric acid, but resists the effects of sulphuric and nitric acids. It would appear that, unlike the other metals mentioned, chromium amalgam cannot be obtained electrolytically by means of a mercury cathode.

A CONDENSER OF VARIABLE CAPACITY.—Mr. C. V. Boys thus describes the condenser he designed to show the effect of condensation in the spark:—"A glass tube is sealed at one end and is covered with tinfoil for one third of its length; this forms the outer coating. The inner coating consists of a test-tube with the rim cut off, also covered with tinfoil; this is fixed to a wire, and can be drawn in and out. When it is fully in, the condenser has its maximum capacity; when drawn out as far as possible, the two coatings are too far apart to have any sensible action, and the capacity is zero. On hanging this on the conductor of a Holtz machine the effect on the spark is well shown. Let the wire be first pushed in as far as possible, the condenser then acts to its full extent; but on gradually drawing it out the sparks are less and less bright, but follow one another more and more rapidly, till at last, when it is fully out, they have passed gradually to the almost continuous pale spark so characteristic of a Holtz machine. To show the effect best, the poles should not be more than about half an inch apart. Of course, much ozone is formed inside the tube."

CONSTANT BICHROMATE BATTERY.—At a recent meeting of the Physical Society, Dr. Erck exhibited a bichromate of potash battery, which he believes to be very constant. The ordinary bichromate battery soon loses power when in use, and in order to secure a powerful constant battery to drive a small astronomical clock, Dr. Erck devised the modified form shown. It consists of a narrow lead trough, twelve inches long by three inches wide and one inch deep, lined along both sides with the carbon plates. The zinc plate, ten inches long, is immersed in the solution, to the depth of an inch, midway between the two carbons. A continual circulation of the bichromate solution is kept up by allowing fresh solution to drop into the cell at one end, and the exhausted solution to drop away by a tap at the other end. As the space between the two carbons is only about half an inch wide, there is merely a thin layer of solution between the positive and negative poles. The internal resistance of the cell is, therefore, very low when short circuited, only about a quarter ohm. To obtain the maximum current, about eight ounces of solution per hour should be supplied. Dr. Erck also showed a battery formed of zinc and carbon circular plates mounted on an axle, which is rotated by wheelwork, thus ensuring contact of saturated solution with the plates of the cells.

THE ELECTRIC LIGHT AT WESTGATE-ON-SEA.—During the month of December, last year, an interesting experiment in electric lighting, on a practical scale, was carried out at Westgate-on-Sea at the instance of Mr. Edmund F. Davis, of St. Peter's, Isle of Thanet. Mr. Davis was desirous on private, and no less on public grounds, of solving the problem of gas *versus* electricity for lighting purposes, and placed the matter in the hands of Mr. W. H. Bennett, C.E., and Mr. W. A. Valon, C.E., to test. Those gentlemen have now issued a voluminous report giving the results of the trials, and from that document the following particulars are taken. The Jablochkoff electric light was selected from amongst the others now before the public, and six lamps were fitted up in the Sea Road. They were placed 80 feet apart and each contained four Jablochkoff candles, the current being produced from a 6-light Gramme machine, which was driven by a portable engine of 10 horse-power nominal, made by Messrs. Garrett and Co. There were two attendants, one for the engine and the other for the machine and the lamps. The current was divided into two circuits, three lamps being placed on each circuit. The experiments commenced on the 2nd of December and were continued for twenty-four nights, the lamps being lighted for four hours each night, thus giving a total of ninety-six hours. Upon eight occasions during the trials, candles went out, which is attributed to faulty carbons. Each time a lamp went out all the others on the same circuit were also extinguished. Photometric experiments gave each lamp as equal to 197 candles. This was reduced greatly by the glass globe. According to the report, the working expenses for the twenty-four days amounted to £40 9s. 4d., and this sum includes fuel, water, oil, 586 Jablochkoff candles at 8d. each, and the wages of the two attendants. As each lamp afforded a light equal to 197 candles it follows that the illuminating power of the six was equal to 1,182 candles. To produce the same amount of light by gas of the same quality as that at Westgate would require 107½ ordinary street gas lamps, each burning five cubic feet per hour, which of the Westgate quality would equal eleven candles, and at the Westgate price of 6s. 6d. per 1,000 cubic feet would cost £16 15s. 4d. for the ninety-six hours. This shows a balance of £23 14s. in favour of gas at the Westgate high price, but, calculated on the basis of the London price, which is 3s. 6d. on the average, the cost would only be £7 18s. 9d. for gas as against £40 9s. 4d. for the electric light. In the electrical experiment the cost of fuel, water, and oil alone was £7 14s. 8d., which is almost exactly that of the gas as calculated upon the basis of London prices. In order to show the cost of establishing and working six electric lamps for a year of 4,327 lighting hours, upon the basis of the cost of the Westgate experiments, Messrs. Bennett and Valon include the necessary estimates in their report. The buildings, plant, and machinery are put down at £1,522, whilst the working expenses—including interest on that sum at 10 per cent., and depreciation on one set of machinery and lamps—amount to £1,576 0s. 8d., or just upon 1s. 2½d. per light per hour for the 4,327 lighting hours. This is exclusive of interest on working capital and depreciation of buildings and cables. The cost of supplying the same illuminating power with gas, at the Westgate price, is £775 17s. 4d., or, including lighting, cleaning, and repairing, £825 14s. 10d. At London prices, and including lighting, cleaning, and repairing, the cost would only be £427 13s. 3d. The report observes that the liability of the machinery to derangement at any moment, the defective character of the candles, the incessant variation of the illuminating power, want of diffusibility and means of storage, the constant care and attention the lights require, and the enormous cost of producing the light—all unfit it for use as a general public illuminating agent.

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ON CERTAIN MEANS OF MEASURING AND REGULATING ELECTRIC CURRENTS.*

BY C. W. SIEMENS, D.C.L., F.R.S.

The dynamo-electric machine furnishes us with a means of producing electric currents of great magnitude, and it has become a matter of importance to measure and regulate the proportionate amount of current that shall be permitted to flow through any branch circuit, especially in such applications as the distribution of light and mechanical force.

On the 19th of June last, upon the occasion of the Soirée of the President of the Royal Society, I exhibited a first conception of an arrangement for regulating such currents, which I have since worked out into a practical form. At the same time, I have been able to realise a method by which currents passing through a circuit, or branch circuit, are measured, and graphically recorded.

It is well known that when an electric current passes through a conductor, heat is generated, which, according to Joule, is proportionate in amount to the resistance of the conductor, and to the square of the current which passes through it in a unit of time, or $H = C^2 R$.

I propose to take advantage of this well-established law of electro-dynamics, in order to limit and determine the amount of current passing through a circuit.

The most essential part of the instrument is a strip of copper, iron, or other metal, rolled extremely thin, through which the current to be regulated has to pass. One end of this thin strip of metal is attached to a screw, by which its tension can be regulated. It then passes upwards over an elevated insulated pulley, and down again to the end of a short lever, working on an axis, armed with a counter weight and with a lever, whose angular position will be materially affected by any small elongation of the strip that may take place from any cause. The apparatus further consists of a number of prisms of metal, supported by means of metallic springs, so regulated by moveable weights as to insure the equidistant position of each prism from its neighbour, unless pressed against the neighbouring piece by the action of the lever, in consequence of a shortening of the metallic strip. By this action one prism after another would be brought into contact with its neighbour, until the last prism in the series would be pressed against the contact spring, which is in metallic connection with the terminal.

The current passing through the thin strip of metal will, under these circumstances, pass through the lever and the line of prisms to the terminal, without encountering any sensible resistance. A second and more circuitous route is, however, provided between the lever and the terminal, consisting of a series of comparatively thin coils of wire of German silver or other resisting metal, connecting the alternate ends of each two adjoining springs, the first and last spring being also connected to the lever and terminal respectively.

When the lever stands in its one extreme position the contact pieces are all separate, and the current has to pass through the entire series of coils, which present sufficient aggregate resistance to prevent the current from exceeding the desired limit.

When the minimum current is passing, the thin metallic strip is at its minimum working temperature, and all the metallic prisms are in contact, this being the position of least resistance. As soon as the current passing through the apparatus shall increase in amount, the thin metallic strip will immediately rise in temperature, which will cause it to elongate, and will allow the lever to recede from its extreme position, liberating one contact piece after another. Each such liberation will call into action the resistance coil connecting the spring ends, and an immediate corresponding diminution of the current through increased resistance; additional resistance will thus be thrown into the circuit, until an equilibrium is established between the heating effect produced by the current in the sensitive strip, and the diminution of heat by radiation from the strip to surrounding objects. In order to obtain uniform results, it is clearly necessary that the loss of heat by radiation should be made independent of accidental causes, such as currents of air or rapid variations of the external temperature, for which purpose the strip is put under a glass shade, and the instrument itself should be placed in a room where a tolerably uniform temperature of say 15°C. is maintained. Under these circumstances, the rate of dissipation by radiation and conduction (considering that we have to deal with low degrees of heat) increases in arithmetical ratio with the temperature of the strip; the expansion of the strip, which affects the position of the lever, is proportionate to the temperature which is itself proportionate to the square of the current—a circumstance highly favourable to the sensitive action of the instrument.

Suppose that the current intended to be passed through the instrument is capable of maintaining the sensitive strip at a temperature of say 60°C., and that a sudden increase of current takes place in consequence either of an augmentation of the supply of electricity or of a change in the extraneous resistance to be overcome, the result will be an augmentation of temperature, which will continue until a new equilibrium between the heat supplied and that lost by radiation is effected. If the strip is made of metal of high conductivity, such as copper or silver, and is rolled down to a thickness not exceeding 0·06 milim., its capacity for heat is exceedingly small, and its surface being relatively very great, the new equilibrium between the supply of heat and its loss by radiation is effected almost instantaneously. But, with the increase of temperature, the position of the regulating lever is simultaneously affected, causing one or more contacts to be liberated, and as many additional resistance coils to be thrown into circuit; the result being that the temperature of the strip varies only between very narrow limits, and that the current itself is rendered very uniform, notwithstanding considerable variation in its force, or in the resistance of the lamp, or other extraneous resistance which it is intended to regulate.

It might appear at first sight that, in dealing with powerful currents, the breaking of contacts would cause serious inconvenience in consequence of the discharge of extra current between the points of contact. But no such discharges of any importance actually take place, because the metallic continuity of the circuit is never broken, and each contact serves only to diminish to some extent the resistance of the regulating rheostat. The resistance coils, by which adjoining contact springs are connected, may be readily changed, so as to suit particular cases; they are made by preference of naked wire, in order to expose the entire surface to the cooling action of the atmosphere.

In dealing with feeble currents I use another form of regulator, in which discs of carbon are substituted for the wire rheostat. The Count Du Moncel in 1856 first called attention to, and Mr. Edison more recently took advantage of, the interesting circumstance that the electrical resistance of carbon varies inversely with the pressure to which it is subjected, and by piling several discs of carbon one upon another in a vertical glass tube, a rheostat may be constructed which varies between wide limits, according as the mechanical pressure in the line of the axis is increased or diminished. A steel wire of, say, 0·3 milim. diameter is drawn tight between the end of a bell-crank lever and an adjusting screw, the pressure of the lever being resisted by a pile of carbon discs placed in a vertical glass tube. The current passing through the steel wire, through the bell-crank lever, and through the carbon discs, encounters the minimum resistance in the latter so long as the tension of the wire is at its maximum; whereas the least increase in temperature of the steel wire by the passage of the current causes a decrease of pressure upon the pile of carbon discs, and an increase in their electrical resistance; it will thus be readily seen that, by means of this simple apparatus, the strength of small currents may be regulated so as to vary only within certain narrow limits.

The apparatus first described may be adapted also for the *measurement* of powerful electric currents. The variable rheostat is in this case dispensed with, and the lever carries at its end a pencil pressing with its point upon a strip of paper drawn under it in a parallel direction with the lever by means of clockwork. A second fixed pencil draws a second or datum line upon the strip, so adjusted that the lines drawn by the two pencils coincide when no current is passing through the sensitive strip. The passage of a current through the strip immediately causes the pencil attached to the lever to move away from the datum line, and the distance between the two lines represents the temperature of the strip. This temperature depends, in the first place, upon the amount of current passing through the strip, and, in the second place, upon the loss of heat by radiation from the strip, which two quantities balance one another during any interval that the current remains constant.

If C is the current before increase of temperature has taken place; R the resistance of the conductor at the external temperature (T), H the heat generated per unit of time at the commencement of the flow, R′ the resistance and H′ the heat when the temperature T′ and the current C have been attained; then, by the law of Joule, $H' = R' C'^2$. But, inasmuch as the radiation during the interval of constant current and temperature is equal to the supply of heat during the same interval, we have, by the law of Dulong and Petit, $H' = (T' - T) S$, in which S is the radiating surface. Then $R' C'^2 = (T' - T) S$, $C'^2 = (T' - T) \frac{S}{R'}$. But $T' - T$ represents the expansion of the strip or movement of the pencil *m*, and considering that the electrical resistance of the conductor varies as its absolute temperature (which, upon the Centigrade scale, is 274° below the zero Centigrade) according to a law first expressed by Helmholtz, and that we are only here dealing with a few degrees difference of temperature, no sensible

* Abstract of a Paper presented to the Royal Society, January 30.

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error will be committed in putting the value of R for R′, and we have the condition of equilibrium $C'^2 = m\frac{S}{R}$.

$$\therefore\ C' = \sqrt{m\frac{S}{R}}, \quad \ldots\ldots\ (1)$$

or, in words, the current varies as the square root of the difference of temperature or ordinates. For any other condition of temperature T″ we have $C''^2 = \frac{S}{R}(T'' - T)$.

$$\therefore\ C'' = \sqrt{\frac{S}{R}(T'' - T)},$$

and $(C''^2 - C'^2) = (T'' - T - T' + T)\frac{S}{R} = (T'' - T')\frac{S}{R}$, but for small differences of C″ and C′ we may put $(C''^2 - C'^2) = 2C''(C'' - C')$, that is to say, small variations of current will be proportional to the variation in the temperature of the strip.

In order to facilitate the process of determining the value of a diagram in Webers or other units of current, it is only necessary, if the variations are not excessive, to average the ordinates, and to determine their value by equation (1), or from a table prepared for that purpose. The error committed in taking the average ordinate instead of the absolute ordinates, when the current varies between small limits, is evidently small, the variation of the ordinates above their mean value averaging the variations below the same.

The thin sensitive conductor may thus be utilised either to restrict the amount of electricity flowing through a branch circuit, within certain narrow limits, or to produce a record of the amount of current passed through a circuit in any given time.

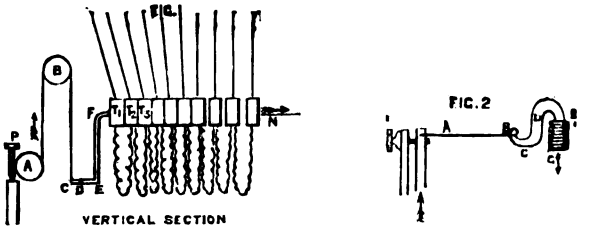
SIEMENS' ELECTRIC CURRENT GOVERNOR.

At the meeting of the Royal Society on the 30th January, Dr. Siemens brought forward an extremely simple instrument for rendering constant a current which, through changes in the electromotive force, or in the resistance of the circuit through which it is flowing or of some parallel circuit, would otherwise have varied. Such a governor would obviously be of great value in regulating the magneto-electric currents employed for the electric light, and especially when several lamps are joined up in series or in parallel circuit.

Various devices have been previously contrived by other Electricians for obtaining an automatic regulator, the principle of all consisting in the insertion of resistance when the current became too strong, and the short circuiting of resistance when it was too weak. In one the current deflected a magnet floating in a liquid in such a way that the more the magnet was deflected by the current becoming stronger the longer, and, therefore, more resisting, became the liquid path through which the current had to flow. In this arrangement, however, the polarisation of the liquid introduced such irregularities that the regulator did not keep the current constant. The current in another passed through the double metal band of a metallic thermometer, one end of which was fixed and the other fastened to a long spiral spring of platinum, the convolutions of which in its normal state touched, and therefore short-circuited, one another. As the current passed through the double metal band the band became warm, and bent, and the more it bent the more the convolutions of the platinum spiral were separated and the greater was the resistance introduced into circuit. This little instrument worked fairly well, but it had the possible objection that unless the platinum spiral was made of thick wire it might not always close up in exactly the same way, so that in its unstretched state it might have slightly different resistances; but if the wire was thick the force necessary to elongate the spiral could not be very small, consequently the strip of two metals composing the thermometer (and the bending of which produced this force) could not be very thin, its mass, therefore, would necessitate an appreciable time for a change of temperature, or the regulator would be sluggish.

The essential principle of all good governors, whether of steam engines or of electric currents, is that the slightest change in the thing to be controlled produces a considerable change in the supply of energy. Now, Watt's centrifugal ball governor, unlike Porter's loaded governor or the parabolic governor, does not fulfil this condition. Undoubtedly, if the speed of the engine increases the increased centrifugal force causes the balls to fly out farther and turn the throttle valve, cutting off some of the steam; but this action is not rapid enough, consequently a considerable variation in speed may occur in an engine controlled with a Watt's governor, comparable, possibly, with the sluggishness of the last mentioned electric current governor.

The idea of employing the stretching of a wire by the heating of the current passing through it was suggested by the early contrivers of electric lamps as a simple means of regulating the distance between the carbons, and it has the advantage that, as the heat produced per second is proportional to the square of the current flowing through it, a very slight change in the current will produce a considerable variation in the quantity of heat produced per second, and, therefore, in the temperature, if the mass of the substance to be heated is very small. On the other hand, when the current diminishes in strength it is necessary that the temperature of the heated substance should immediately fall; this requires considerable radiating surface. These conditions Dr. Siemens has fulfilled in the following instrument, the principle of which is shown in the accompanying figure:—A B C is a vertical band of metal not more than a twentieth of a millimetre, or two-thousandths of an inch thick, passing over the roller B, one end of the band being fixed to the roller A, and the other, C, to the short end of a lever, C D E F, turning on a pivot, D. If now by turning the pinion P the thin metallic band is tightened, the



upper end, F, of the lever C D E F is pressed against the movable metallic terminals T_1, T_2, T_3, &c., of the resistance coils; the result is, these are pushed out of the vertical and pressed together, and all the coils are short-circuited. If now a current, entering at A and leaving at N, passes through the vertical metallic strip A B C, the lever C D E F, and the terminals T_1, T_2, T_3, &c., it heats the strip, which consequently expands and diminishes the pressure of F on T_1; some of the terminals, therefore, separate from one another, and some of the resistance coils are introduced into circuit (in the figure six are shown short-circuited and three in circuit). Resistance will be automatically introduced until an equilibriated state is arrived at, when the heat lost from the metallic strip A B C, by radiation, convection, and conduction is exactly equal to that generated by the current, and any further decrease or subsequent increase of the current (provided the change is within certain limits) will be at once checked. To provide against accidental charges in the radiating power of the strip, produced by currents of air, &c., the portion A B C is under a glass cover.

In some trials made with this instrument before the Royal Society it was shown that the interposition of a certain resistance into the circuit only altered the deflection of a tangent galvanometer from 40° to 39·5° when the regulator was employed, whereas without it the insertion of the same extraneous resistance diminished the deflection from 60° to 40°.

Figure 2 shows another form of governor proposed by Dr. Siemens. The wire A B is stretched until the lever C D E turning on the pivot D produces sufficient pressure on a pile of Edison carbon discs in the glass tube G. This pressure becomes less, and the resistance of the carbons becomes greater the more the wire stretches by heating with the current passing through it and through the carbon discs: the stronger, therefore, is the current the greater is the resistance opposed to it.

Either of these instruments may be used as a *recorder* of the electric current by attaching a pencil to the lever and allowing it to make a continuous mark on a strip of paper moved by clockwork at right angles to the direction of motion of the lever.

THE MERITENS MAGNETO-ELECTRIC MACHINE.

In reply to the questions asked by "A Puzzled Amateur" in our last issue, M. de Méritens writes to us as follows:—

"1. The insulated wires on the cores of the armature of my machine are all wound in the same direction. Only the outer end of the wire of one coil is connected with the outer end of the wire of a coil next to it; whilst the inner end of the wire of the one coil communicates with the inner end of another coil next to it. The alternating currents produced are thus of the same sign throughout the whole ring.

"2. The two terminals of the wire on the ring, which constitute the two poles—the signs of which change every moment, since the currents are alternating—communicate respectively

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with two copper rings fixed on the axis of the machine and insulated from it. Two thick copper wires are in frictional contact with these rings, and are connected to terminal screws, from which the current is obtained, precisely as in the case of the Alliance machine.

"The machine ordered of me for the Royal Institution will have a commutator enabling it to furnish at will continuous or alternating currents, and also 'quantity' or 'tension' currents. This machine is a present from the Duke of Northumberland to the Royal Institution. The machine which I am making for Mr. W. Spottiswoode, President of the Royal Society, is also furnished with the same commutator. The large model of my machine, experimentally tried by Mr. Douglas, chief engineer of the lighthouses, has given most extraordinary results.

"Should you require further particulars, I hold myself at your disposal. "A. DE MÉRITENS."

THE ELECTRIC LIGHT.*

By WILLIAM HENRY PREECE, M.I.C.E., V.P. Soc. T.E.,
Electrician General Post Office.

Those who live in the present day have good reasons to be thankful for the luxuries and comforts which science has bestowed upon them to improve their health, to cleanse their bodies, to economise their time, to transport their frames and their thoughts from place to place, and to enable them to live, move, and have their being in pure air, in cheap clothing, and in bright light. In days of old that which has given us soap, steam, gas, and electricity would have been deified, but the day for the apotheosis of Science has not yet come. Science remains the delight of the few, the fear and scorn of some, the mystery of many. The finest disciplinary agent for the mind, the great searcher for truth, the great inspirer of awe and reverence remains untaught in our schools, unappreciated in our legislative assemblies, unused in our pulpits.

If any one wishes to know how our great grandfathers moved about in the dark, let him go to the National Gallery, examine Hogarth's pictures, and wonder how the pleasures of society could possibly be conducted in such obscurity. Boswell tells of "a very fashionable baronet" who preferred "the smell of a flambeau at the playhouse" to the fragrance of a lovely May evening. Even now our noses are sometimes assailed by the sputtering tallow and the smouldering snuffers of our childhood. Prior to 1832 our candles were taxed, and the poor were compelled to dip their own rushes. Now, thanks to the greater brilliancy of gas, exciting emulation and enterprise, the removal of excise restrictions, the ingenuity of Palmer, Price, Field, and others, our poor can luxuriate in greater luminous brilliancy than the nobility of a hundred years ago. Oil lamps were not introduced into the streets of London until the reign of Charles II., and then they were only lit from Michaelmas to Lady Day, and only from darkness till midnight even then. The poet Gay speaks of the public streets—

> "Where oily rays,
> Shed from the crystal lamp, o'erspread the ways."

And there are many of us in this hall who perhaps can remember towns which were so lit to within a comparatively recent period. Gas was introduced in 1802 by Murdock, and it was employed practically for the first time in lighting up Boulton and Watts' new steam engine manufactory in Soho, Birmingham. The electric arc was discovered about the same time by Sir Humphrey Davy, so that we have this strange fact, that steam, gas, and the electric light were introduced at the same time.

Thus the electric light is no new thing. It has remained the plaything of the philosopher for seventy years. It has scarcely made any advance within this last twenty years, and, in reality, we know nothing more about it now than we did in the year 1862 when it was exhibited at the International Exhibition. How is it, then, that there has been such a scare amongst those who are interested in gas? In the first place, those who visited Paris were charmed and delighted by the brilliant display made at enormous cost by our friends on the other side of the Channel, an effect which was very much enhanced by the clearness and beauty of the magnificent new street that the Parisians had just constructed. Again, the tremendous sensation produced by the telephone and phonograph had excited astonishment at the novelties produced on the other side of the Atlantic, and wonder at what was next to appear; so that when a newspaper telegram was received announcing that Mr. Edison, the inventor of the phonograph, had made some new discovery in electric lighting, and was able to multiply the light *ad infinitum*, so as to entirely displace gas, timid gas shareholders lost confidence in their property, and threw their stock broadcast upon the market.

* Lecture at the United Service Institute.

It is amusing to find how these scares have been repeated periodically. We read in 1848 and 1849:—"Very recently, how much unnecessary alarm has been created by a few cleverly written newspaper paragraphs about the electric light. Nothing could more clearly demonstrate the sensitiveness of gas proprietors than their conduct on that occasion. In the largest and most prosperous companies, both in the metropolis and the provinces, shares fell 25 to 30 per cent., and in a few days, whilst contracts were deferred, and works actually in progress were hastily suspended."

Again, in 1857, we read that M. Jobart, addressing the Belgian Academy of Sciences, said:—

"I hasten to announce to the Academy the important discovery of the dividing of an electric current for lighting purposes. This current, from a single source, traverses as many wires as may be desired, and gives a series of lights ranging from a night lamp to a lighthouse lamp.

"The luminous arc between two carbons produces, as is well known, a very intense, flickering, and costly light. M. de Chanzy, who is a chemist, mechanician, and physicist, is thoroughly conversant with the latest discoveries, and has just solved the problem of dividing the electric light.

"In his laboratory, where he has worked alone for the past six years, I saw a battery of twelve Bunsen elements producing a constant luminous arc between two carbons in a regulator of his own invention, this regulator being the most simple and perfect I have ever seen. A dozen small miners' lamps were also in the circuit, and he could at pleasure light or extinguish either one or the other, or all together, without diminishing or increasing the intensity of the light through the extinction of the neighbouring lamps. The lamps, which are inclosed in hermetically sealed glass tubes, are intended for the lighting of mines in which there is fire-damp, and for street lamps, which would by this system be all lighted or put out at the same time on the circuits being opened or closed. The light is as white and pure as Gillard's gas, with which it has one point in common, viz., its production by the incandescence of platinum. The gas-pipes are replaced by simple wires, and no explosions, bad smells, or fires can take place."

In 1862 we had a grand display in our own Exhibition. The electric light was used during the erection of Westminster Bridge in 1862-3, and the metropolis was illuminated in several places by its means during the rejoicings attending the marriage of the Prince of Wales in 1863. In 1876 we had a very good display at the Loan Exhibition in South Kensington. Now the public mind is becoming so educated to the use of the electric light, and manufacturers have taken up the matter so warmly, that we may probably look upon the electric light as being the accepted light for certain purposes.

Now, let us ask ourselves this question—What is light? It is one of those forms which that all-pervading agent, called energy, assumes to render matter evident and useful. Matter, by energy, is compelled to assume certain motions which at one time give us those effects called heat, at another time light, at another time electricity, and so on. But heat and light are identical in character, though different in degree; and whenever solid matter has imparted to it motion of a very high intensity—in other words, when solid matter is raised to a very high temperature—it becomes luminous. The amount of light is dependent upon the height of this temperature; and it is a very remarkable fact that all solid bodies become self-luminous at the same temperature. This was determined by Daniell to be 980°, by Wedgewood 947°, by Draper 977°; so that we may approximately assume the temperature at which bodies begin to show a dull light to be 1,000°. The intensity of light, however, increases in a greater ratio than the temperature. For instance, platinum at 2,600° emits forty times more light than at 1,900°. Bodies when raised to incandescence pass through all stages of the spectrum; as the temperature increases, so does the refrangibility of the rays of light. Thus, when a body is at a temperature of—

Temperature.	
250°	it may be called warm.
500°	,, ,, hot.
1,000°	we have the red rays.
1,200°	,, ,, orange rays.
1,300°	,, ,, yellow rays.
1,500°	,, ,, blue rays.
1,700°	,, ,, indigo rays.
2,000°	,, ,, violet rays.

So that any body raised to a temperature above 2,000° will give us all the rays of the sun. Inversely, the spectroscope may thus be enabled to tell us the temperature of the different lights, and it is, perhaps, because some lights do not exceed 1,300° that we lose all those rays beyond the yellow.

(TO BE CONTINUED.)

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

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Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

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A SUPERANNUATION FUND.

We have before us the report of the proceedings of the Twelfth Annual Meeting of the "Telegraphers' Mutual Benefit Association," held at New York Nov. 20, 1878. This report compels us again to acknowledge that we have much to learn from our cousins across the Atlantic, and we have need to carefully study their institutions. The *raison d'être* of this institution seems to be to enable its members to make some provision for those dear ones who may survive them in the struggle for life. It is, however, hardly to be called an insurance society, although, practically, it has insurance for its object. Its management differs from that of an ordinary insurance office, where you pay periodically a certain specified premium. The amount due to the heirs of a deceased member, if exceeding that in the society's hands, is obtained by a levy or levies upon each member. Besides the sum obtained from such assessments, a further sum is received from initiation fees and from interest. The statistics of this society for 1878 show that there were 1,886 members at the end of the year, an average of 1,840 members during the year, 222 new members admitted, and 12 applications for readmission. The receipts obtained from initiation fees were 553 dollars, from assessments 26,561 dollars, and from interest rather over 1,224 dollars, making a grand total of some 28,338 dollars. The amount paid to heirs during the year was 24,800 dollars. The whole of the business was transacted at an outlay of only 1,319 dollars. The death list during the year has been an exceptionally heavy one, numbering twenty-seven. "Of these," says the president, "eight fell from yellow fever in the south. . . All who died of yellow fever were men of excellent average constitution, who, had they been less noble, might have saved their lives by flight, but who chose to die at their posts of duty. . . Notwithstanding the extreme mortality of the year, the assessments have been only fifteen, averaging 1 dollar 25 cents a month to each member, or one and one-half per cent. on the death payment." The secretary, in his report, says; "Many members look lightly upon the Association's affairs, deeming them small matters, but a moment's reflection should convince them of the error. We are carrying nearly 2,000,000 dollars of risks. The receipts and disbursements during the past year have been 30,000 dollars, and since the organisation of the Association one hundred and twenty-five families have received the benefit of its membership, amounting to 122,514 dollars, few of whom have looked upon the amount accruing to them as a 'small affair;' and no tongue can tell, no pen portray the relief, which has been given to many otherwise helpless *beneficiaries*." The letters we have at various times published show that the *employés* of English companies have a feeling of disquietude respecting the future of themselves and families which they would like to see removed. The scheme, however, which they desire is not exactly similar to that which has been tried in America, but more of the mixed character of an annuity and an insurance. Thus one writes: "I look upon it as of the greatest importance to all, and especially to those who have spent the best years of their life in an Eastern climate; let that climate be never so good, we do not look forward to ending our days in it, and naturally wish to spend the last years in the old country. Without a pension there is no chance of this; the pay we get will not allow of saving much, indeed not enough to provide for the rainy day, which, in the ordinary course, we must all expect, sooner or later, to overtake us." Some of our correspondents seem to think that the initiative should come from the various boards of directors. We fear they cannot have looked upon the question in the right light, and we, therefore, feel no hesitation in returning to a subject we have more than once before referred to. Under ordinary circumstances, each man in the employ of a company has an exact market value. It is, however, generally possible for a servant, who has mastered his work, to make himself more valuable than the new comer. He has, we will suppose, to transact business in a foreign country. The people around him have their peculiar idiosyncrasies, which it is his duty to study, and use the knowledge thus gained for his master's welfare. If business is slack, he may be able to induce more business, but only if he has gained the complete confidence of those among whom he labours. An operator may thus prepare the road to become a superintendent; and, depend upon it, in these days of excessive competition, directors are keenly alert to the necessity

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of having men about them who take an interest in their work. It is not enough that John Smith has such and such duties to perform, and performs them. Perfection is a long way off yet, and John Smith will undoubtedly make improvements in his work if he is interested in it. We will suppose the men to be all competent, to have had their salaries increased from time to time as they proved their worth, and still to find that the future looms dark and drear. The initiative must again come from them—they must show their willingness to be mulcted in small sums, and to undergo present privations, in order to clear the clouds from the evening of their days. If the men do not show an unanimous desire to do this, do they think their directors will take upon themselves to force men in the way which cannot but prove beneficial—has one *employé* in a hundred hitherto expressed his opinion that the directors of his company would even be justified in looking a little closely into his private affairs? As we have stated before, we have every reason to believe that the greater number of directors are quite willing to consider any representation made by their *employés* on the subject of a superannuation fund. How such a fund is to be managed, is a question that cannot be answered till it be certain that it is wanted. The present time may, perhaps, not be the best to bring the subject before the notice of directors, since it is a period of great financial depression, by no means favourable to very liberal co-operation, even on the part of those who might be liberally disposed; but the *employés* should prepare and consider their plans so as to have them ready to bring forward at the first favourable opportunity.

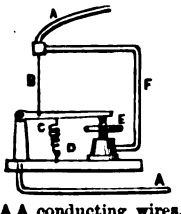
CORRESPONDENCE.

EDISON'S CURRENT REGULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The "wonderful" regulator devised by that "wonderful" demolisher of gas companies, Mr. Edison, of which mention is made in your issue of December 28th—in an article from the *New York Herald*—is made as follows:—

His sheet of irridio platinum is rigidly affixed, at the top, to a crossbar, to which is attached one wire. The crossbar at the bottom, to which the lower edge of the sheet and the other wire are attached, is a lever drawn down by a spring. Underneath this lever is an adjustable screw, tipped with platinum. From the standard of this screw runs a shunt wire to the top of the sheet. As the sheet is heated it expands, and the spring on the lever draws it down. The shunt screw is set to the desired degree of heat (light), and when this is reached the lever is in contact with the screw, and the current is shunted out of the sheet. In practice, this contact is being constantly made and broken. There you have the key to this "wonderful" performance. But in all the accounts published of what Mr. Edison is about to accomplish, the question of cost is carefully avoided, and the fact that he is endeavouring to procure a cheap light by the most expensive electrical method is entirely ignored. The nearest approach to a confession was made in a newspaper the other day, in these words:—"Mr. Edison will not make his light public until he has succeeded in producing it at a lower rate than gas. Until then we must wait."



A A conducting wires, B edge of illuminating sheet, C lever, D spring, E shunt post, F shunt wire.

To which I would ask, "How long, O Lord, how long?"—Yours, &c.,

AN AMERICAN.

B. A. UNITS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to point out an error in a back number—No. 20, page 236. In the list of British Association Units, No. 4, the microfarad is stated to be 10^{-3} M.G.S. units. An inspection of the fraction will show that it should be 10^{-13}.

Yours, &c.,

W. KINGSLAND.

School of Telegraphy, 4, George-street, Hanover-square, W., Feb. 1, 1879.

ELECTRICAL "POTENTIAL."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the article under this heading in your last issue (p. 131), will you allow me, in the first place, to protest, as an electrician, against the expression "tension of a current" employed, to my great surprise, by so high an authority on all electrical matters as M. du Moncel. The only differences known in science between constant currents are those of *magnitude* and *density* (the former difference being that expressed by the terms "intensity" or "quantity" in English, and by "*intensité*" in French); and I have no hesitation in stating that the expression "tension of a current" cannot be justified by any scientific definition.

In regard to the employment of the term "potential" instead of "tension," I have always held, and still hold, that there is no *raison d'être* for the former outside of its application to a particular mathematical expression for *tension*. No doubt, the latter term has been abused, notably in the erroneous statement so often made that the tension of a charge is greater where a conductor is *pointed* than at other (flatter) portions of its surface; but this can scarcely be accepted as a sufficient reason for the substitution of another term, quite as open to misconception, having a particular application, and of which the general signification is precisely that of "tension." Thus "electromotive force," formerly defined as the algebraic "difference of tensions," has obtained a second definition as "difference of potentials;" and, according to this definition and Euclid's first axiom, "potential" must here be the same thing as "tension."

I am convinced that there are many persons in this country who use the word "potential" solely from imitation, and because they imagine it to have a more learned sound than "tension." This affectation of science is easily detected by requiring a rational definition and a concrete application of the term used.

What M. du Moncel says of "potential" is generally applicable to "tension"; but the equations for the latter are simple, readily comprehended by the student, and constitute an expression of physical fact. The tension between two conductors, A and B, charged from the opposite poles of a source, is measured by $E = Q\,R = D\,l\,k$.* Let $R = r + r_1$, then the tension between A and earth, or what is termed the tension of A, will be

$$T = E\frac{r}{R} = Q\,r.$$

And the tension of B will be

$$T_1 = E\frac{r}{R} - E = E\left(\frac{r}{r + r_1} - 1\right).$$

In the case of prismatic resistances, when both conductors are insulated from earth,

$$T = T_1 = \pm\frac{D\,l\,k}{2}.$$

—Yours, &c.,

DESMOND G. FITZGERALD.

A NEW FORM OF ELECTRIC LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Under the above heading Mr. T. P. B. Warren has in the last number of *The Electrician* described a rough kind of "Electric Lamp," which he says he "devised," and which is in some degree similar to that just brought before the French Academy of Sciences, by M. Ducretet.

Permit me to inform your readers that a similar idea, that of floating the lower carbons upon mercury, but without certain disadvantages inseparable from the plan described in your columns, was designed and put into actual operation by Mr. W. Lascelles Scott as far back as last June, and was, together with other discoveries and contrivances of the same gentleman, patented several months ago.

On the occasion of Mr. Shoolbred's paper at the Society of Arts, I attended, and was prepared to give evidence of the above and certain collateral matters (of which, if I am not mistaken, you, Sir, were likewise cognisant), but although I twice sent up my card to the chairman I was not permitted to speak.

I do not desire upon the present occasion to enlarge this brief but necessary letter into a detailed description of the "Electro-Calcic Light," but inasmuch as under this system we can divide the current into so many "lights," adapted either for large areas or for small apartments, that I will not put it into figures,

* Here E is electromotive force $[\pm T - (\mp T_1)]$; Q is the quantity of electricity which has been set in motion in the inductive circuit by the action of E; R is the total inductive resistance of the circuit; r the inductive resistance to the accumulation of a charge in A when B is to earth, and r_1 the corresponding value in the case of B when A is to earth; D is the density of the charge; l the *length* of dielectric (distance between opposing surfaces) in the case of prismatic resistances, or the reduced length—*longueur réduite*—in the case of non-prismatic resistances; and k is the specific inductive resistance of the dielectric.

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lest your readers should think I was putting their credulity to too great a strain at this stage—that we can vary the *tint* of the light at pleasure, that we can *diffuse* it not only without losing 70 per cent. of its brightness, but with a positive *gain* in illuminating power; and that the cost of Electro-Calcic Lighting will be only from about double (as now incurred by existing patents) to something like *half* the cost of gas. I may state that as soon as the necessary funds are subscribed, I hope to announce a public demonstration of this new and practically successful method of electric lighting.—Yours, &c.,

RAYMOND C. HAYNES,
Sole Agent for the Patent Electro-Calcic Light,
74, Coleman-street, London, E.C.

January 28th, 1879.

ON THE EXCITATION OF ELECTRICITY AT THE CONTACT OF SOLIDS AND GASES.

BY W. BEETZ.*

(CONCLUDED FROM P. 130.)

Measurements executed with the positive electrode gave indefinite results. The plates immediately became brown and strongly negative, so that I obtained for the force Zn | Pd_O values like 2·12 D. In correspondence with this, for the total polarization Pd_H | Pd_O very great forces were found; but I convinced myself that their numerical evaluation was of no importance, since here not the action of gaseous active or passive oxygen comes into consideration, but that of the deposited layer of oxide. On this account, of the numerical data obtained by other observers on the strength of the polarization on palladium plates, I can only compare one with my own results: Graham†, namely, found that the polarization produced by from 1 to 4 Bunsen elements was

Pd_H | Pd_O 1·50 — 1·85 D.

I find, on electrolysis by 4 Grove or 6 Meidinger,

1·83, 1·77,

Mean ... Pd_H | Pt_O = 1·80 D,

therefore, very nearly the same as Graham; but the platinum plate was not polarised to the maximum. A statement made by Pearnell‡, according to which the polarisation

Pd_H | Pd_O = 0·306 D,

is evidently much too low.

Covering palladium with palladium-black made no alteration in the polarization by hydrogen. Böttger§ gives proofs of the powerful polarization of such blackened palladium plates; but the prominent action comes into consideration only when the closing of the current is continued, while with the monetary closing required by the compensation method it is of no importance. The palladium-black covering the positive electrode is immediately pushed off; the layer of oxide which forms completely exfoliates the black coating.

Of other gases, I have caused chlorine, carbonic oxide, ethylene, and sulphuretted hydrogen to act upon palladium.

The action of chlorine commences with the first traces that enter the fluid and are absorbed by it, and is strongly negative. When the fluid was saturated with chlorine there appeared the electromotive force

Zn —Pd, Cl = 2·04 D;

on the combination standing longer the force certainly continued to rise, but only slightly. Accordingly

Pd | Pd, Cl = 0·76 D.

The attempt to polarize palladium with chlorine by electrolysis of hydrochloric acid had to be given up as useless. Even chlorine gas introduced from without into the gas element attacked the palladium and browned both the metal and the liquid after a time; while in the electrolysis the attack commenced immediately and with violence, and a coating of palladium-black was at once driven off.

Ethylene and carbonic oxide gas, introduced into the tube containing a platinum plate, polarized it positively: indeed, after introducing the ethylene, I found the values

1·22, 1·24, 1·23,

Mean ... Zn | Pd, C_2H_4 = 1·23 D;

and after the introduction of the carbonic oxide,

1·05, 1·06,

Mean ... Zn | Pd, CO = 1·05 D.

Therefore

Pd, C_2O_4 | Pd = 0·05 D,

Pd, CO | Pd = 0·23 D.

When sulphuretted hydrogen was brought into the tube, I obtained immediately after the appearance of the first bubble the tension-difference Zn | Pd, H_2S = 0·88 D.

On continually agitating the liquid with fresh quantities of gas until it was saturated, the above difference was scarcely altered; after two successive fresh saturations I obtained 0·87 and 0·87; so that we have Pd, H_2S | Pd = 0·41 D.

The carbons with which I have experimented were four-edged rods of retort-carbon, such as are used for electric lamps. They are of great hardness and very close structure. They were purified by boiling in nitric acid, in water, and lastly in dilute sulphuric acid, in which they were then left to cool. If they were to be used in dilute hydrochloric instead of sulphuric acid, this liquid was then the last in which they were boiled. Through this treatment the rods were pretty homogeneous. Introducing them into dilute sulphuric acid, and uniting this by the siphon with the zinc-cell, I obtained the following electromotive forces:—

1·32, 1·33, 1·28, 1.30, 1.30, 1·29,
1·27, 1·27, 1·38, 1·37, 1·37, 1·32.

Mean ... Zn | C = 1·31 D.

For each series of experiments fresh carbons had to be employed, as the carbons, altered by the various actions which they had undergone, could not be again brought into their initial condition. Oxygen or hydrogen, led into the tubes enclosing the carbons, produced not the slightest result; the electromotive force of the combination remained quite unaltered = Zn | C. The behaviour of carbonic oxide and ethylene gas was just as indifferent. These results do not accord with my earlier experiences, according to which the gases mentioned acted as electromotors on Bunsen's carbon also, and by which I was induced to assume that the electromotive forces of carbon batteries composed of different metal (or carbon) plates, but of the same gases, stood in a definite relation, dependent on the condensing force exerted by the metals upon the gases. The carbons with which I worked thirty years since were very porous—battery carbons prepared from coke and coal; and at that time I said that the coefficient of condensation which I found for my carbons was certainly not to be regarded as holding good generally, but that other carbons might behave differently. Thus, with those now used such proportionality is altogether out of the question; the gases employed cannot have undergone any condensation upon the carbon. In order to test this rather unlikely fact more minutely, I cut out of such retort-carbon two regular shaped pieces, each of 0·5 × 0·5 centim. cross section and 1 centim. length, the solid content of each being thus 0·25 cub. centim. These pieces were strongly heated and then introduced into ammonia gas which was enclosed in measuring-tubes over mercury. After the old temperature was fully restored, the volume of the ammonia gas had increased by a minute quantity which could not be precisely determined with the altered form of the meniscus. Had the increase amounted to 0·25 cub. centim., it would have been a proof that in fact no gas was absorbed; still the experiments showed that the retort-carbon had taken up as good as none of even this gas, which is briskly absorbed by the other sorts of carbon.

Very different was the behavour of the carbon to chlorine. This gas was conducted into the tube of the element until it was no longer completely absorbed; then the connection of the conducting liquid with the zinc-cell was restored, when the following tension-differences were found:—

1·97, 1·97, 1·94, 2·01,

Mean ...Zn | C, Cl = 1·97 D;

from which it follows that

C | C, Cl = 0·69 D.

When the chlorine was not brought into the tube from without, but evolved immediately at the carbon electrode by electrolysis of diluted hydrochloric acid, still greater electromotive forces were obtained—namely,

2·13, 2·25, 2·18,

Mean ... Zn | C_{Cl} = 2·19 D.

With longer-continued polarization Macaluso observed yet higher values.

That carbon electrodes are strongly polarized by electrolysis in dilute sulphuric acid is already known; Dufour*, particularly, has recently called attention to it. I found the polarization for both electrodes together

2·08, 2·21, 1·96, 2·04,

Mean ... C_H | C_O = 2·07 D.

After restoration of the connexion with the zinc-cell, there was found for the polarization of the negative electrode—

0·27, 0·26,

Mean ... Zn | C_H = ·26 D;

and for the positive—

2·16, 2·38,

Mean ... Zn | C_O = 2·27 D.

* Translated from Wiedemann's *Annalen*, 1878, No. 9, vol. v. pp. 1-20, in *Phil. Mag.*, Jan. 1879.
† *Phil. Mag.* [IV.] xxxviii. p. 243.
‡ *Phil. Mag.* xxxix. p. 52.
§ *Jahresber. d. Frankf. ph. Ver.* 1875-76, p. 23.

* *Bull. Soc. Vaud.* [2] xix. p. 63 (1876); Wied. *Ann. Beiblätter*, i. p. 573.

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Further, by direct comparison were found:—the force between pure carbon and carbon polarized with hydrogen—

1·07, 1·11,

Mean ... $C_H \mid C = 1·09$ D;

and between carbon pure and polarized with oxygen—

1·07, 1·04,

Mean ... $C \mid C_O = 1·05$ D.

Hence we should have

$$C_H \mid C_O = 2·14 \text{ D},$$

while 2·07 had been found directly.

When the carbon electrodes at which the electrolysis had taken place were left in position, their difference of tension in comparison with pure carbon diminished only slowly and imperfectly. The carbon at which hydrogen had been evolved showed still, after twenty-four hours, tension-differences against pure carbon amounting to about 0·6 D, while that at which oxygen had been evolved showed about 0·3 D. Evidently, however, further chemical changes had taken place in the carbons:—in the negative, probably reductions of metallic oxides mixed with it in spite of all the purification it had undergone; in the positive, conversely, oxidations. An electrolysis, between carbon electrodes, of dilute sulphuric acid delivered, during the same time in which at platinum electrodes 27·36 cubic centims. of hydrogen were separated by the same current, 26·86 cubic centims. of hydrogen, but only 1·71 cubic centim. of oxygen. For the reduction, therefore, but very little hydrogen was consumed, and so much the more oxygen for the oxidation; indeed it was the carbon itself that was oxidized, forming carbonic acid and carbonic oxide gas. When, as in the present experiments, small quantities of gas are separated from large masses of conducting liquid, the carbonic acid is all absorbed; but if by long-continued electrolysis of a neutral-salt solution (for instance, Glauber salt) larger quantities of gas are evolved, the gas which collects above the liquid contains considerable amounts of free carbonic acid, which can be removed by agitation with caustic potash. The remaining gas proves to be carbonic oxide. The proportion of the two gases to one another appears to depend on the density of the current.* At the same time the carbon anode is violently attacked and carbon powder copiously thrown off from it, like the palladium dust thrown off from the oxidizing palladium plate; while the surface of the carbon becomes coloured deep blue. Macaluso has also observed this destruction of the carbon with the evolution of chlorine at a carbon electrode.

Different again, lastly, was the behaviour of carbon to sulphuric acid. After a few gas-bubbles had made their appearance at the carbon (just as before, with palladium), no change was shown in its electromotive position. As the diluted sulphuric acid was repeatedly shaken with fresh quantities of sulpuretted hydrogen the carbon continually approached nearer to the positive end of the tension-series; there were observed, namely, for $Zn \mid C, H_2S$:—

At the commencement	1·29
After the second saturation..	1·13
After the third	1·04
After the fourth	1·02

Thus, with the saturation of the solution, the electromotive force approached towards a limiting value which is to be set down as about

$$Zn \mid C, H_2S = 1·02 \text{ D}.$$

so that

$$C, H_2S \mid C \text{ becomes} = 0·29 \text{ D}.$$

The electromotive forces which were called forth at the palladium by hydrogen, sulphretted hydrogen, carbonic oxide, and ethylene show, in fact, again a similar proportionality, as I had previously conjectured for all the metals. In the following table I place side by side the values before found for platinum and those now found for palladium, and calculate from the forces observed at platinum those to be expected at palladium, by multiplying the former with the ratio.

$$Pd \mid Pd, H : Pt \mid Pt, H = 0·59 : 0·81 = 0·73.$$

	Pt. Found.	Pd. Found.	Pd. Calculated.
H.....	0·81	0·59	0·59
H_2S	0·69	0·42	0·50
CO	0·28	0·23	0·20
N_2H_4	0·06	0·05	0·04
Metal	0	0	0

For the retort-carbon, on the contrary, nothing similar is to be observed; its state was in general changed *only* under the influence of greater solubility of the gases of the electric polarization. Besides, we have no longer any right to designate the factor 0·73 as the coefficient of condensation for palladium, since we know that palladium condenses hydrogen much more strongly than platinum does.

From the results obtained the following is now evident:—Platinum, palladium, and carbon behave to chlorine exactly alike, so much so that the numerical values found for the electromotive forces Zn | Pt, Cl; Zn | Pd, Cl; Zn | C, Cl stand very near to one another; they amount to 2·08, 2·04, 1·97 D respectively. The values which were obtained on the electrolytic evolution of chlorine are here left out of consideration, because the attack which therein took place on the electrodes makes the comparison unsafe. The almost perfect agreement between Pt, Cl and C, Cl was also remarked by Macaluso*. It looks as if the plate dipping in the chlorine solution served solely as a conductor; and in fact we cannot here speak of the electromotive force excited by a gas, but have simply to do with the electromotive action of a liquid, which increases with the degree of concentration of the liquid.

The solubility of sulphuretted hydrogen in water is similar to that of chlorine; but it behaves otherwise to platinum and palladium than to retort-corbon. The latter, again, occurs only as a body immersed in a solution, by which it is the more intensely electrically excited the more concentrated the solution. Platinum and palladium are already strongly excited by the first quantities of gas; they evidently draw it from the liquid to condense it in or upon themselves.

The rest of the gases which have been taken into consideration are but little soluble in water. Of course, in the usual form of the gas battery, something even of these must at first be dissolved in the conducting liquid in order to become active; but the quantity is too inconsiderable to cause the solution to act on the conducting plate essentially otherwise than the liquid which has absorbed no gas at all. In these cases something else must come into play to generate a difference of tension—namely, either an affinity (or, gererally, an action of molecular forces by which the gases incorporate themselves with the metal plate), or the action of an electrolyzing current which either drives the gases into the metal or condenses them upon its surface. On palladium hydrogen exhibits this penetration in the highest degree, on platinum in a less degree, on retort-carbon not at all. The aid of galvanic polarization is superfluous with palladium, useful with platinum, absolutely necessary with retort-carbon to generate a difference of tension. Carbonic oxide and ethylene act in the same manner as hydrogen, but far more feebly. If we could condense them by galvanic polarization, it would in all three cases be useful; with carbon, indeed, it would be indispensable. Sulphuretted hydrogen stands, with reference to its behaviour to platinum and palladium, near to hydrogen, and near chlorine in consequence of its solubility.

I made an experiment to ascertain if chlorine, which so readily attacks the surface of metals, penetrates also into or through them. Exactly as in Root's experiment, two glass vessels were cemented to the two sides of a much broader sheet of palladium *b*. Both vessels were filled with diluted hydrochloric acid; and palladium electrodes *a* and *c* dipped into them. Between *a* and *b* a current was closed, so that chlorine was evolved upon the side of *b* turned towards *a*. On the other hand, *b* and *c* could be connected with the galvanometer by momentary closings. To my astonishment, after a time there was shown an electric difference in which not *b* but *c* appeared negative. Of the liberated chlorine traces passed through the atmosphere to the surface of the liquid in the other vessel, and through it arrived at the electrode *c*. That slight traces of chlorine act at once electromotively on platinum also had already been remarked by Macaluso; and I am now of opinion that the oxygen gas which I used for my first measurements on gas batteries, and which had been prepared from chlorate of potass, always carried with it traces of chlorine, although I thought I had sufficiently purified it by washing; for with oxygen obtained by electrolysis I could as little excite platinum electromotively as palladium. I now altered my apparatus by giving it the form of a U-shaped tube, the horizontal part of which, 80 centims. long, was divided in the middle by a thin plate of palladium into two halves. I first filled both sides with diluted sulphuric acid, and evolved hydrogen at the side of *b* facing the plate *a*, and that by closing the circuit for only a few seconds. The action of hydrogen that had penetrated through the palladium was very soon perceptible; the plate *b* also became positive on its reverse side. The experiment cannot be long continued; for the plate bends so much that it soon breaks loose from its attachment. A fresh tube was now filled with diluted hydrochloric acid. The long layer of liquid permitted none of the evolved chlorine to escape, while the electrode *c* remained perfectly indifferent until the plate *b* was eaten

* In consequence of the complete disappearance of the gas in my first experiments, I at first thought that the carbon itself was not oxidized at all. An incidental communication from M. Laurent, Ingenieur, of Belfort, who had observed the occurrence of carbonic oxide and acid on electrolysis at carbon electrodes, induced me to repeat my experiments on a larger scale. I intend to carry them on still further.

* *Loc. cit.* p. 362.

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quite through. In order to fix more exactly the instant at which this took place, I filled the vertical parts of the U-tube up to different heights (*i.e.*, one leg of tube to a higher level than the other), and repeated the experiment. Again *b* and *c* remained indifferent to one another; suddenly there was a violent deflection of the galvanometer mirror; but at this moment the liquid on both sides began to place itself in equilibrium. According to these experiments, chlorine does not penetrate palladium as hydrogen does.

From this I think I am warranted in maintaining, generally, that, strictly speaking, we never have to do with any electromotive force of gases, but either with tension-differences called forth by conducting liquids of different kinds, or with alterations of metals by gases which have lost their gaseous state by occlusion in, or condensation on the suface of, metals; for an actually coherent layer of gas that covered a metallic conductor would surely insulate it from the conducting liquid.

I will here add the description of an experiment which I made long ago for the purpose of getting an explanation of the activity of gases in the gas battery. Gaugain, in the paper above mentioned, has advocated the view that the electromotive force of the gas battery is to be attributed solely to the chemical affinity with which the oxygen of the water and the hydrogen condensed by the platinum act on one another. To this I objected that this proposition must be generalised, since other gases also act as electromotors; it must, therefore, be expressed something like this :—A gas acts as an electromotor through combining, under a catalytic co-operation of the platinum, with one of the elements of the water.* Whether this proposition is correct can be ascertained by the following experiment. In a dark room I filled up two tubes, in each of which was a platinum plate, and containing, as usual, diluted sulphuric acid with chlorine. The two plates showed no difference of tension. I now covered over one of the tubes with a yellow glass bell, and let the daylight fall upon both tubes. Certainly the action of the chlorine upon the hydrogen of the water was now much more vigorous in the free than in the covered tube; but no difference of tension was visible. For chlorine, therefore, the above proposition is certainly untenable. To hydrogen it is, indeed, still less applicable, since otherwise the affinity of the hydrogen on the platinum for the oxygen of the water would have to be greater than that of the oxygen for the hydrogen already combined with it.

I remark finally, in reference to Graham's statement (already called in question by G. Wiedemann†) that palladium charged with hydrogen is strongly magnetic, that I have never succeeded in detecting any action of hydride of palladium upon the magnetometer.

After the above communication had been presented to the Royal Academy, I received the April number of the *Philosophical Magazine*, in which Mr. Morley publishes an investigation, carried out by him in Professor Foster's laboratory, on Grove's gas battery. Mr. Morley is only acquainted with the older writings of Grove and Schönbein and the newer ones of Gaugain; mine he seems never to have seen.

He, likewise, controverts the view that the seat of the electromotive force in gas batteries is the place of contact of metal, liquid, and gas; but he comes to the conclusion which, in the present communication, I have declared is not universally valid —that the entire current of the gas battery owes its rise to the dissolved gases. At the same time he does not admit that the gradual falling-off of the current of a closed gas battery is to be attributed to polarization coming in, but seeks its cause solely in the diminution of the volume of gas dissolved in the liquid. As, however, he does not measure the electromotive forces by momentary closings of the circuit, as Gaugain and I have done, but calculates them from the current-intensity observed during a continued closing, and from the resistance, it is not possible from his measurements to distinguish the primary from the secondary actions. That a mixture of this sort has not been avoided is shown also by the proposition at which Mr. Morley arrives :—that the electromotive force of the gas battery is not constant, but increases with the resistance.

Munich, May, 1878.

THE EASTERN TELEGRAPH COMPANY (LIMITED).

The Half-yearly General Meeting of the Shareholders of the above Company was held on the 30th January, under the presidency of Mr. J. Pender, M.P., chairman of the Company.

The notice convening the meeting was read, and the minutes of the last ordinary meeting, held on the 11th January, 1878, and of the extraordinary meeting, held on the 9th of August, were read and confirmed.

The CHAIRMAN then said: Gentlemen, I shall, as usual, give you a few figures, so that you may be able to judge for yourselves of the working of the Company since I last had the pleasure of addressing you. The receipts from messages during the half year ending September last amounted to £206,295, against £250,528 in the corresponding half of 1877, and £235,848 in the previous half year—the March half of 1878. The revenue for the March half year is, as a rule, very much better than for the September one, and, no doubt, this will be the result for the current financial period. In comparing September, 1878 with September, 1877, it must be remembered that the Indo-European lines were totally interrupted for a period of three-and-a-half months in 1877, and this being before the joint-purse agreement came into force, the whole of the receipts from the Indian and trans-Indian messages belonged exclusively to the Eastern Telegraph Company—a most exceptional circumstance, and one not likely to occur again, as we have now an arrangement with the Indo-European Company. About £42,000 should be deducted from the account for the half year ending September, 1877, as representing the additional revenue derived by the breakdown of the other routes before comparing it with the receipts of the past half year. We thus have here a figure of £208,528, which is about £2,000 more than we earned last half year. Our revenue, however, suffered to a far greater extent than £2,000 by the falling off in our traffic with India and the East. We have been and are still passing through a season of bad trade. When business improves, there can be very little doubt that our traffic will grow at least to its former dimensions, and if we can hold our own the shareholders will, no doubt, eventually be satisfied. A large portion of our diminished revenue from Indian messages has been made good by other sources of income, which did not appear in the accounts for 1877, to which I shall refer in the general remarks I make hereafter. The receipt from messages sent over the Black Sea cable is £4,600, the receipt from messages from and to Turkish stations since the laying of our new cables has been £4,500; the return to us on the £74,000 we gave for the Black Sea cable since we took over that line on the 15th August to the 31st December last has been at the rate of over 20 per cent., so that what I asked you to sanction six months ago has proved a very satisfactory bargain, and I only hope that it will go on in the same way, though I cannot expect it. We have lost £2,413 on our remittances, chiefly from India; this, I am glad to say, is likely to be corrected in future, as we have come to a fixed rate with the Government. Now, gentlemen, our total expenses amounted to £79,220, against, in September, 1877, £130,974, or a decrease of £51,754. The main item of decrease is in repairs to cables, which in the half year to September, 1878, amounted to £20,154, against, in September, 1877, £74,835, or a decrease in the half year we are reviewing of £54,681. The repairs during the present half year consist chiefly of repairs to the Red Sea cables, amounting to over £16,000, the balance being the cost of several small repairs in the Levant. The general expenses in London amounted to £6,425, against £6,208 in Sept., 1877, or an increase of £217. With the exception of salaries and wages, which show an increase of £89, office expenses an increase of £45, and repairs and renewal of furniture, &c., £78, the other items are about the same. Salaries and wages and offices expenses are increased, owing to extra clerkships, stationery, and petty charges, &c., and to certain alterations which had to be done at the expiry of our lease. I could give you all the items, but they are small sums, and I do not think it is necessary to detain you with them. The working expenses at stations amounted to £44,455, against £39,791 in September, 1877, or an increase of £4,664. The largest item is the "maintenance and renewal of land lines, instruments, &c.," which shows an increase of £2,460, caused principally by our replacing with iron poles a portion of the Egyptian land lines. Salaries and wages show an increase of £1,766; rent, fuel, and light, an increase of £429. These two increases are attributable to our having opened seven new stations. Repairs to stations show an increase of £408, principally at Suez and Aden. These are the leading features of the increases and decreases of the last six months. And now, before I ask you to approve or vote on the resolution before you, I may make a few general remarks, and state that the value of our telegraphic communications with India at the present moment, and during the last two or three months, must be apparent to every one. I only hope that the Imperial Government appreciate it as the public have done. What would have been our position to-day if we had this Afghan war without our having any daily communications such as we have, and with such troubled times as we have at home? I suspect that, bad as the times have been, and anxious as men must have been in times such as we have been passing through, the anxiety in the country at large must have been intensified had we been dependent on the old system of communication with India. There is a point that I have always looked on as a very important point, and I wish the Press especially to notice it. It is that we have always at this Board been in favour of giving the Press certain advantages. We believe that the more information that we can pass through the Press the better will be the appreciation of our system of telegraphy. We have urged strongly that during the spare hours which we have—and there are many, because the cables which we have now are quite equal to doing much more work than they have to do—during those spare hours we think we can employ them profitably by giving the Press very considerably reduced rates. We proposed quarter rates, and that plan is working now in the most satisfactory way between England and America. We have tried to bring this about—we have been particularly anxious to bring it about here, but we have had serious difficulties. First, our own Government were not quite in accord with us, but, after due consideration both in England and India, have agreed with us to the quarter rates, and the party that is opposing now is the German Government. They will not concede the quarter rates—they stand to half rates—and, therefore, we are still using all the arguments and influence we can to induce that Government to adopt the quarter rates. My own impression is that by giving the Press quarter rates we shall not lose, that we shall give an enormous impulse to telegraphy generally, and you will find columns of matter in the papers from day to day, whereas at the present moment you only get limited extracts. Therefore, as I have said, I desire that the Press should take special notice of this, because I must tell the Press plainly and honestly that we have got very little support indeed from them. We have done everything in our power to help them, but they have done very little to help us, and I think it is better that we should come to an understanding with one another—help us, and we will help you. I will, however, say that notwithstanding the high rate they have had to pay for Indian messages passed over our lines, one newspaper has paid £200 for a single message,

* Pogg. *Ann.* cxxxii. p. 458.

† *Galvanismus*, 2nd ed., vol. 1. p. 528; cf. Blondlot, *Beibl.* vol. i. p. 634.

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and I think that shows enterprise which is worthy of being mentioned, and I think that where such enterprise is shown they are entitled to every possible consideration. Our system during the last six months, like every other institution in the country, has more or less suffered. When I tell you that there are firms in London which have paid us as much as £10,000 a year for telegraphing to India, and when I tell you that the depression of trade has been such as to cripple very materially some of those customers, and, in other cases, unfortunately to wipe them out for a time altogether, you can well understand the decrease which has taken place in our Indian traffic. But although some of our customers that were giving us £5,000 and £6,000 a year have for the moment ceased to give us employment, you see that there are others springing up; and when the good times come I have no doubt that the whole of our traffic will come back with the usual increased per centage. At the present moment we are suffering very materially from the state of things I mentioned to you, but at the same time I am glad to say that the other lines which we have opened up, viz., the line to Constantinople, the Sea of Marmora line, which we have completed since I last had the pleasure of addressing you, the Cyprus line, which has answered us fairly well, and the one at Salonica, which is doing fairly well —in fact, we have such a system in the Mediterranean that we have recuperated pretty well what we have lost in India; and when good trade returns we may, I think, look forward to a fairly increased revenue. Now, I think with these remarks I have pretty well exhausted all that I have to say. Our cables are in fair working order. We have in these shallow waters—we probably always shall have—our repairing ships constantly at work. If we could only do without repairs our success would be much more marked, but in shallow waters we must expect these breakages. However we can generally repair the breakages in a few days. Our breakages are not usually in deep water, or repairs would be more costly and often impossible. With these remarks, I now beg to propose the resolution, which is "That the report and accounts of the Directors to the 30th of September, 1878, now submitted, be and they are hereby received and adopted."

The Marquis of TWEEDDALE: I beg to second that.

The CHAIRMAN: If any gentleman wishes to make any remarks on the report, or upon any of the remarks which I have made, I shall be very glad to hear him.

A SHAREHOLDER: I think I understood you to say that as to the ordinary expenses there is very little difference between September, 1877, and September, 1878? I make a difference of £8,500, not in the special expenses, but in the ordinary.

The CHAIRMAN: I will look into that. We have the accountant here, and he will see.

Mr. NEWTON: I have given you notice of a resolution which I intend to propose at this meeting. Shall I have an opportunity of doing that after the adoption of the report?

The CHAIRMAN: The letter which Mr. Newton addressed to the Board of Directors came after the last Board rose, so it has been before the Board to-day, and I may mention that with every desire to meet the wishes of the shareholders, or even of an individual shareholder, we are bound by our articles of association. If there is any desire to alter these articles of association, and if the honourable shareholder will take the course which is indicated in those articles, it will have the most respectful attention of the Board. I have no objection even to go further than that, and let the hon. gentleman make his statement to-day, that we may know what he desires, and if there is any expression of opinion on it I shall be very glad to hear it. At the same time it can only be conversational, because we cannot come to any resolution unless that resolution is in conformity with our articles of association. I think the hon. gentleman will see that I am making a statement that must be acceptable to the body of the shareholders, without the slightest desire to throw any difficulty in the way.

Mr. NEWTON moved an amendment "That the accounts and balance-sheet, together with the report of the directors, with the exception of the eighth paragraph relating to the re-election of the retiring directors, be received and adopted." He complained against the articles of association, and expressed himself annoyed at the manner in which his remarks at a previous meeting had been published. He also objected to the remarks made by the solicitor at the last general meeting, at which he (Mr. Newton) was not able to be present. Mr. Newton further expressed his dislike to directors with titles being on boards, urging that mercantile men with commercial experience should take the place of some of the present Board. He was proceeding to a review of the past career of Baron Erlanger when——

The CHAIRMAN interrupted him, saying: I really think that the meeting has listened long enough to this sort of conversation, and it is, after all, a repetition of what you have said on other occasions. It is a grievance you have, you have stated it before, and you are taking up the time of the meeting. It is entirely irregular. We have allowed you to ventilate your feelings, but I must ask the meeting whether we are not bound by the articles of association. If you wish any alteration made in them go about it in the proper way. We are quite ready to meet it in a fair way. I don't wish to avoid discussion; but I said Mr. Newton might put before the meeting, which he has not yet distinctly done, what he wishes to alter, and the meeting might take it into consideration to-day, knowing what his views were, and if he got the requisite number of signatures to carry that out they would know how to act. I have dealt with the shareholder fairly.

At this period of the meeting a desultory conversation took place between several shareholders and the chairman relating to the re-election of directors. The discussion on expenses was then resumed.

A SHAREHOLDER: I wish to make a few remarks, but first, perhaps, I had better explain my position as a shareholder, as the solicitor might wish to know [laughter]. I hold 100 shares, and I think I have £2,500 of the new debentures. I am sorry that I have not the comparison with the previous half year, but I find that the general expenses in London are very much increased, and I also find that our working expenses have increased to the extent of £5,000. I have also found, as you have, that our receipts have diminished—very materially. I find, as Mr. Newton has found, that the cost of maintenance of ships is entirely left out. Why? I find also that the balance carried forward is only £3,400, and nothing goes to the reserve fund. I think we have heard it said before at telegraph companies that the "life" of a cable is ten years generally.

The CHAIRMAN: That is said of Atlantic, deep-water cables.

A SHAREHOLDER: Then we understand that cables laid in shallow water last very much longer, although the repairs are very much more frequent?

The CHAIRMAN: No doubt.

A SHAREHOLDER: Because at the rate stated as to the life of a cable we should require half a million as reserve instead of a few thousands. Then, with all this and a reduced number of directors, I find their remuneration remains the same [hear, hear]; the number has decreased by one-eighth, but the amount paid them remains the same. I must express my great astonishment at that when you take your enormous salaries at telegraph companies, although whether you have allowed that to escape your attention I don't know; but if I were in your places I should regard it as a very serious matter. I certainly do think when you see things as unfavourable as stated in this report that every effort should be made to cut down expenses. In all companies with which I am connected if the receipts diminish the expenses are made to correspond. I fully enter into the questions of Mr. Newton. I do think that you ought to be especially careful in the directors you choose to act in harmony with yourselves, and if there is any personal question against a gentleman I certainly think it would be a good opportunity for you to introduce it now. I am very sorry to find almost the same board of directors—I will not say "fastened on," but fixed on in some way that the shareholders cannot get rid of them—in nearly all the telegraph companies that there are. In railway companies there are different boards of directors, and we get men of intelligence, of strict honour, and of great business capacity working some of the railways up to good positions; but telegraph companies seem all under one sway, and we are going worse—from 7 per cent. to 6 per cent., and from that to 5 per cent. It is, too, a most risky property, and now we have no reserve fund we shall, it seems, go down to 4 or 3 per cent.

Mr. PRICE: At the last meeting I called attention to the matter of the Cyprus cable, and I want to call attention to it again. The chairman kindly gave us the figures in regard to the Black Sea cable, about which the opinion expressed at the last meeting was very favourable on the part of the shareholders; but there was a very unfavourable opinion expressed on the part of many of the shareholders with regard to the Cyprus cable, and we have had no detailed account from the chairman to-day of the actual receipts and the position of the cable [hear, hear]. I do not think myself that it will pay. I said so at the last meeting. In addition to our not having any account, and in addition to the expenditure already made, I find in the report another paragraph about it. "In accordance with arrangements made with Her Majesty's Government the Company has connected Cyprus with Alexandria by cable, and is now constructing land lines in the island." Now, I think that that is a very ominous paragraph. If it means anything, it means that we are going to have a network of lines in the island of Cyprus. If we had the line to Cyprus, which was the matter I understood at the last meeting, I think that we shall have quite enough to send off all the traffic that we can get from that place; but now it appears that we are to have a lot of stations in the island, and consequently larger expenses. I hope, sir, that you will be able to re-assure us on that point. In this balance sheet, in these accounts, and in the accounts for the last one or two half years, we have had the expenses of repairs to the cables all lumped up. I think it used to be the practice—I know it was—to show the amount to each individual cable, so that then we knew something about our property, which we don't now. I also find the cost of the new cables and the increase to the capital is all lumped up, and I hold that it would have been very much more satisfactory to us if we had it stated in detail—it would only take two or three items to do that, and then we should have the information. Here it stands as "Cost of extensions in the Levant and payments on account of Cyprus and Black Sea cables," all lumped together. I think it would only take two or three items to have that item stated separately, and that would give us a better notion of our property. Another small matter—but still I should like to mention it—is that it is the practice of the Board to send out with all these reports a proxy to each shareholder. I consider it is a waste of money.

In reply to criticisms,

The CHAIRMAN said: The progress that is taking place in telegraphy is, perhaps, the most remarkable of the present century; and if I took—I did some twelve or eighteen months ago—the trouble to show you the figures I could show you that, if our returns to-day were based on the principles we laid down in our prospectus, we should have been paying you 30 per cent. instead of 5 per cent. The cause of the reduction in the revenue is, to a very large extent, on account of the cleverness which people have shown in coding messages. Two or three words now represent many pages of matter, and all this is done at our expense. We have to contend against all that, and still we have maintained a fair position. I have never said that we ought not to have a better dividend; but we cannot contend against circumstances over which we have no control. Would raising the tariffs meet it? [A voice, Yes.] All I can say is, that is not my opinion or experience. Now, as to the terrible remarks of the falling off of £5,000 in your receipts, I have shown you that where we have lost at one point, we have recouped it; and I have also spoken of the state of things in this country and India; and any one not knowing that, is not competent to form an opinion, for he is entirely ignorant of circumstances affecting such enterprises as these. As to the remarks of Mr. Price upon the Cyprus cable, it is just laid, and so far as we see yet, we expect fully that it will give us a fair return; but take the Cyprus cable in connexion with the circle of cables there—take the Black Sea cable doing 20 per cent.—we can afford to wait a little till the Cyprus cable has developed. A telegraph, like everything else, does not come into account fully at once —it requires a certain amount of "nursing;" and we all know that Cyprus is comparatively new, but if there is any growth through British management there will be a large increase in telegraphing.

A SHAREHOLDER: If I remember aright it has been laid for over three months, according to the report.

The CHAIRMAN: Well, it is something like £5,000 a year. It cost £60,000, and the Government paid half of that. If you take £5,000 a year on £30,000 you will see if it is paying. We have many things to contend with in these times. I am quite prepared to substantiate anything we have brought before the shareholders as showing that it was deserving of attention, but we cannot fight against the coding. The one word message has been adopted and approved generally, and as long as we have that one-word message—you know that one word can represent a very large amount of matter. As to the land lines in Cyprus, after all, that is a question

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which I do not expect to pay yet. They are only half made. The line to Limassol will be completed this week. They will probably cost us £8,000, and if we get nothing from them for a year or two, the £400 a year is all that we lose by it. But at the same time, if we on the land lines get a few messages, if they are sent over our general Mediterranean system, and to England it tells very much in favour of those lines, although small in value in itself. We felt that it was very much better to expend the £8,000 in land lines than let it go into the hands of others, who might become an opposition, instead of playing into our own hands, for we know that it is not pleasant to have a Government with a long purse to oppose us. Some remarks have been made that in these bad times there ought to be an alteration in the directors' remuneration. All I can say is that I go to these offices every morning, and often leave very late in the afternoon, and no man occupying such a position in commercial life would do what I have done for three times the amount of money.

The discussion continued as to the right to use proxies.

Sir JAMES ANDERSON: With regard to the maintenance of the ships they are now reduced to a sum much less than they are worth. They could not be replaced for under £80,000 or £90,000, and they are set down at £63,000, so you see there is no necessity to write off so much as you were in the habit of doing. I, therefore, said to the auditors that if we wiped off £2,000 at the end of the year that would be sufficient to make our ships stand very well indeed. I did not think, too, that it was proper to advise the wiping off of anything for depreciation this half year, which is always the worse half. The current half will be better. The ships are now below their value in the balance sheet.

The CHAIRMAN: As to the directors' fees the sum was originally £5,000 a year, and it was reduced to £4,000.

A SHAREHOLDER: I think, sir, that you cannot be surprised that the shareholders, under all the circumstances, should be very dissatisfied with the results. No doubt there are many excuses to be made, but I think that the shareholders have been led on to believe that this concern would have been very much more profitable than it has turned out. The expenses, too, have grown upon us to a very considerable extent, and I think, sir, that it behoves the Board to bear with a little temper while we complain of these things. Only yesterday I saw in the newspaper that we have an establishment and superintending telegraphist on the island of Scio—a little island, somewhat smaller, I believe I am right in saying, than the Isle of Man. I should apprehend that an establishment on the island of Scio could not be much less than £1,000. I will not ask you whether Scio does return us £1,000 a year, but I will ask, is it possible that any one believes that Scio will ever return us £1,000 a year? I think, sir, that a great deal of our money has been wasted in these Levant cables, and I would press on the directors most strongly to see whether a great many of these amounts cannot be readily suppressed.

Sir JAMES ANDERSON: The island of Scio is the main line which takes us to Smyrna, and, therefore, to Constantinople by that route. It forms an alternative route to Constantinople. ["Why have an establishment there?"] We have always had it. It has also become the centre and principal island of Turkey in the Levant. Rhodes used to be. It is a very important island, and one of the best in the whole of the Levant, and I only hope that the Levant traffic may remain as good as it is, and, if so, you will not have to regret it. It has saved us from the loss of revenue we should otherwise have had this year owing to the depressed trade with India.

After further conversation, the CHAIRMAN moved, "That the Right Hon. W. N. Massey, M.P., who now retires, be and is hereby re-elected a director of the Company."

Sir JAMES ANDERSON: I second that.

The Right Hon. W. N. Massey, M.P., was re-elected, as was the Marquis of Tweeddale. In the latter case a poll was demanded, with the following result:—For the resolution, shareholders present holding 1,369 shares; proxies 137,191, making a total in favour of the Marquis of Tweeddale's re-election of 138,560 votes; and there were against three shareholders holding together 210 shares.

The proceedings then terminated.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).

The sixth ordinary general meeting of the shareholders of the above Company was held on Friday, the 31st of January, at the Cannon-street Hotel, Mr. Henry Rawson, the chairman, presiding.

The report of the directors stated that the total earnings for the year ended 30th of September last were £92,882, the working expenses (including £1,737 rebate on issue of A B and C debentures), charged to revenue, were £72,552; the A B and C debenture interest for the year was £17,066, leaving a net balance of £3,263 to the credit of revenue account. The revenue showed a falling off compared with the previous year of £5,652.

The CHAIRMAN, in moving the adoption of the report, said the directors had tried to the utmost to carry on the affairs of the Company, and if they had failed in securing a good profit last year, it was from no fault of their own, but from circumstances over which they had not, and could not possibly have, any control. He then referred to the stagnation in commercial affairs, and the difficulties against which they had had to contend through the numerous interruptions of their cables and other misfortunes. During the last twelve months they had relaid 830 miles of their cables, 730 of which were entirely new sheathed, and it had all been done with from £24,000 to £25,000 supplied by the shareholders. When he told them that 830 miles formed a third of their entire system, and that the whole of their system had cost them £1,700,000, they could not say that on this occasion they had not done the work most economically. It was very satisfactory to know that in the deep water they found that the original cable was very good. During the next year he thought they might hope to earn as good a revenue as could be earned from their lines. With respect to their capital account, they had made a debit of £70,000 for laying the cable into Marunham, according to the terms of the concession. If they had had a better revenue account he would have preferred to put the whole of this to that account, although it actually belonged to capital account. Ships and lighters remained at £42,000, and the auditors remarked that nothing had been allowed for depreciation on them, but his own opinion was that as soon as they could they should wipe this item off altogether. He then referred to other matters of interest to the shareholders, and said, with regard to the decrease in the revenue, that, considering the interruptions to their line, the account was not unsatisfactory.

Mr. HENRY WEAVER having seconded the motion,

The CHAIRMAN, in reply to a question, said they had tested their cables to a very great extent, and found them better than they expected they were twelve months ago. In twelve months' time they hoped to be out of debt and difficulty.

The report was then adopted, and the meeting separated.

COMPANHIA TELEGRAPHICA PLATINO-BRASILIERA.

The half-yearly general meeting of the shareholders of the above Company was held on Friday, the 31st of January, at the offices, 66, Old Broad-street, under the presidency of Mr. J. Pender, M.P.

The CHAIRMAN first referred to the meeting which was held at the Cannon-street Hotel, at which a committee was appointed to look after the Company's affairs. Everyone was disappointed with the Company's position, and nothing of a satisfactory character could be got from Messrs. Grant Brothers, and they thought it was time that a board should be constituted in London. From the time the committee was appointed he and his colleagues had been working assiduously to get the Company into a business-like shape. They were obliged to work under Brazilian statutes, as they were a Brazilian Company, and this had occasioned difficulties. A third of the whole of the shares had to be represented before a meeting could be legally constituted, and it would be remembered that at the preceding meeting they had to wait an hour or two for a quorum. They were now taking steps to have the Company constituted under English law, and in six months hence he hoped they would accomplish that object. The accounts, as obtained from the Messrs. Grant, had been referred to Messrs. Norton, Rose, Norton, and Brewer, and Messrs. Deloitte, Dever, Griffiths, and Co.; and he could only say as to those accounts that if telegraph companies generally had been conducted on the same principle as this had been, they would not have been in a very satisfactory state that day. The accounts were not such as any business men could wish to have presented to them in future. He had not to ask the shareholders to approve the accounts, but to refer them to a fiscal committee, who would report to the shareholders as to them; and on that report they would be asked to confirm the report and accept the accounts. It had been considered well to get a complete report of the land line system in the Brazils, and this report had only come to hand that morning. The letter accompanying it seemed to be of a satisfactory character, and he hoped by the time the fiscal committee issued their report that the Board would be in a position to present the shareholders with a well-considered report upon the state of the land lines in the Argentine Republic. The Board recommended Sir James Anderson, Mr. Beaton (of the Brazilian Bank), and Mr. Burt, as the fiscal committee.

On the motion of Mr. MORRISON, seconded by Mr. SANDERSON, these gentlemen were duly elected; and

The CHAIRMAN then moved a resolution constituting five shareholders as a quorum for the general meetings, and this was passed.

A vote of thanks to the chairman then terminated the proceedings.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES FEB. 5.		BUSINESS DONE WEEK ENDING FEB. 5. Highest.	Lowest.
Anglo-American	59½,	60	59½	58
Do. "B"	85½,	½	86½	83½
Do. "A"	34½,	½	34½	32½
Brazilian	6½,	½	6½	6½
Cuba	8¼,	9¼	8 13-16	8 3-16
Do. Ten per Cent. Preference	15¼,	¼	15¼	15¼
Direct Spanish	1½,	2	—	—
Do. Ten per Cent. Preference	9½,	10½	—	—
Direct United States ex div.	11½,	½	11½	10½
Eastern	7½,	½	7½	7½
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do. ex div.	100,	103	102½	101½
Do. Six per Cent. Preference	11½,	½	11½	11½
Eastern Extension	7 1-16,	3-16	7 3-16	7
Do. Six per Cent. Debenture ex d.	105,	108	108½	108½
German Union ex div.	7½,	8	7½	7½
Globe Telegraph and Trust	5,	¼	5½	5
Do. Six per Cent. Preference	10½,	¼	10½	10½
Great Northern	7½,	8½	8	8
Indo-European	19½,	20½	—	—
Mediterranean Extension	2½,	3½	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	10,	11	—	—
Submarine	220,	225	221½	221
West India and Panama	—,	—	—	—
Do. Six per Cent. Preference	8½,	¼	8½	8½
Western and Brazilian	2½,	3½	2 15-16	2½
West. Union Seven per Cent. 1st Mort.	114,	118	—	—
Do. Six per Cent. Sterling	101,	103	—	—

TRAFFIC RECEIPTS FOR JANUARY, 1879.

COMPANIES.	Jan. 1879.	Jan. 1878.	Incrse.	Decrse.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,900 estd.	3,001	—	101
Direct Spanish Telegraph Company	951	944	7	—
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	24,695	22,905	1,790	—
Eastern Telegraph Company	—	—	—	—
Great Northern Telegraph Company	13,856	13,511	345	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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NOTES.

THE ROYAL INSTITUTION.—The President, the Duke of Northumberland, having presented the Royal Institution with a Meritens' machine, we shall, doubtless, soon have full details of experiments, enabling us accurately to obtain the real value of the machine.

ELECTRICITY.—Lord Elphinstone and Mr. C. W. Vincent, F.R.S.E., recently (Jan. 27) obtained provisional protection for new means of producing electric currents. We are informed that the inventors expect to materially reduce the cost of apparatus and force expended.

MUIRHEAD'S QUADRUPLEX.—The new system of quadruplex telegraphy now being brought out by Dr. Muirhead, conjointly with Messrs. Winter and Briggs, is based on the split battery system of duplex which has been lately applied successfully by Mr. Briggs, of the Government Telegraphic Service, on various lines in India. Its chief merit is the wide working limits of the balance. We hope shortly to publish a full description. This system is not intended to be applied to cable work.

STEELING COPPER PLATES. (By R. Böttger, *Chem. Centr.*, 1878, 687.)—100 parts of ammonio-ferrous sulphate and 50 parts of ammonium chloride are dissolved in 500 parts of pure water, a few drops of sulphuric acid are added, the liquid is maintained at 60° to 80°, and the copper plate is immersed in this liquid, and is made the cathode of a system of two or three Bunsen's cells, the anode consisting of an iron plate equal in size to the copper. In a few minutes the copper plate becomes covered with a hard steel-like deposit of iron.

PLANTÉ'S SECONDARY BATTERY.—According to Planté, if two spirals of thin sheet lead immersed in dilute sulphuric acid are connected with the wires from a battery, the anode spiral becomes covered with lead peroxide, and the cathode with a grey compact film. If the battery be disconnected when oxygen begins to be evolved at the anode, the lead spirals act as a powerful battery, and retain their electromotive force for some days. M. Böttger finds, however, that the electromotive force diminishes rapidly, and that after twenty-four hours no further action is obtainable from such an arrangement.

MAGNETIC ELEMENTS, &c.—Mean declination or variation of the compass at Greenwich, 18° 45′ W. Inclination or dip of the needle, 67° 35′. Intensity or mean horizontal force (in British units), 3·91. The above elements are for Greenwich, or for places very near to it. To find the true, or astronomical north, from the magnetic, all that is necessary is to place the compass on a level surface, and turn the card round until the marked end of the needle points 18° 45′ towards the west; then the zero point of the card will be in the direction of the true, or astronomical north, while the needle itself will be pointing to the magnetic north.

METALLIC CHROMIUM.—In the *Philosophical Magazine*, 1862, Vol. 24, p. 328, Charles W. Vincent describes the process for producing this metal from a solution of the chloride which has lately been made the subject of a memoir to the Académie des Sciènces, by M. H. Moisson, and an abstract of which appeared in *The Electrician* on Feb. 8. Mr. Vincent says:—"By adding to a solution of the chloride of chromium an amalgam of sodium, I have found that although there is a considerable waste of sodium, nevertheless an amalgam of chromium remains, which on distillation in a tube retort filled with naptha vapour, yields this metal in a finely divided state."

THE POST OFFICE AT NEW YORK.—The main floor of this building is to be lighted by means of the electric light. In England, the postal authorities prefer to wait till the light is perfect before experimenting. The policy is penny wise and pound foolish. A good electrical engineer could easily and satisfactorily light up the instrument room at St. Martin's-le-grand, and the cost would be little, if at all, above that of gas. If we consider the decreased strain upon the eyes of the operators employed, the better ventilation obtained, and other obvious advantages, we do not hesitate to say that such a room should be lighted by electricity, at least experimentally.

THE MERITENS' MACHINE AT THE ROYAL INSTITUTION.—After Professor Tyndall's lecture it was desired to make some experiments with this machine. For this purpose we believe M. de Meritens prolonged his stay in England for a few days. The small machine was found to give a light equal to 1,500 candles, a little less than the Alliance machines used in the lighthouses. The power employed was a little more than 1 h-p. instead of from 3·5 h-p. to 4 h-p. required by an Alliance machine, giving a similar light. The large machine, at the first trial, gave a light equal to 8,500 candles, increasing at the second to 10,000 candles. Mr. Douglas expressed great satisfaction with the machine.

NONSENSE.—Some of our young amateurs, and some of our ignorant editors, seem determined to write and publish the most astounding nonsense that can be obtained with regard to the electric light. A short time ago several papers advocated the idea suggested by a youthful bicyclist that a small dynamo-machine should be connected with the wheels of the bicycle, and a light obtained. Now ordinary carriages are to be fitted with electric lamps, and also railway trains. We wonder whether the method of these statements is not that by making enough of them (the wilder and more improbable the better), some may hit a mark, and the producer be rewarded. Railway trains may be furnished with the electric light, provided a special engine be carried in the guard's van; so may a carriage, if Jehu has an engine under the hammar cloth; but a bicycle—never.

ALARM PRODUCED ON THE DISCOVERY OF THE LEYDEN JAR.—In describing the effect produced on himself by taking the shock from a thin glass bowl, Muschenbrock stated in a letter to Réaumer, that "he felt himself struck in his arms, shoulders, and breast, so that he lost his breath, and was two days before he recovered from the effect of the blow, and the terror," adding, "he would not take a second shock for the kingdom of France." M. Allamand, on taking a shock, declared "that he lost the use of his breath for some minutes, and then felt so intense a pain along his right arm, that he feared permanent injury from it." Winkler stated, that the first time he underwent the experiment, "he suffered great convulsions through his body; that it put his blood into agitation; that he feared an ardent fever, and was obliged to have recourse to cooling medicines." The lady of

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this professor took the shock twice, and was rendered so weak by it that she could hardly walk. The third time it gave her bleeding at the nose.

Electro-Magnets in Telegraphy.—Mr. O. Heaviside, writing to the *Philosophical Magazine*, says:—"In a recent number of this journal I stated: 'On telephonic circuits the reduction in current strength is nearly inversely proportional to the pitch of the sound,' &c. This is true only for a constant electromotive force. Thus, it would be correct for a battery telephone. The strength of very rapid currents from a battery through an electro-magnet is nearly inversely proportional to the rapidity. But in an electro-magnetic telephone, although the electromotive *impulse* produced by a semivibration of the iron disc of the sending telephone is *constant* for all pitches, provided the amplitude of the vibration is the same, yet, when the semivibration is executed in half the time, the mean value of the electromotive force is doubled. Thus, instead of the second partial tone of a continuous sound being weakened nearly twice as much as the first, it will not be quite so much weakened. Γ being the current, R the resistance, L the electro-magnetic capacity, and $m = \frac{2\pi}{T}$, where T is the time of a complete vibration, then

$$\Gamma = \frac{m\,E}{\sqrt{R^2 + L^2 m^2}}$$

in the case of a Bell telephone, where E is proportional to the amplitude of vibration of the sending disc. Keeping E constant, Γ increases slightly with m. Also, when R is increased, Γ is reduced more for low pitches than for high."

Comparison of the Variations of the Diurnal Range of Magnetic Declination at Kew and Trevandrum.—It became obvious (say Prof. Balfour Stewart and Morisabro Hiraoka, in a paper presented to the Royal Society, and establishing a comparison between the results obtained at Kew and Trevandrum), that the turning points in the curve which represented the variations of the Kew declination-range were, on the whole, in point of time before the corresponding points in the Trevandrum curve. While this result might have been rendered evident by making the numbers of the tables of means at once into curves, yet it was found to become more apparent to the eye and freer from inequalities by adopting a certain amount of equalisation. Accordingly, the Kew and Trevandrum tables were transformed into others with the same time-interval between their numbers as in the originals, but each number in the transformed table being the mean of nine consecutive numbers in the original table. Curves were then plotted from these transformed tables. A comparison of the curves appears to lead to the following conclusions:—(1) Generally speaking, maximum points or risings in the one curve must be associated with maximum points or risings in the other, rather than with minimum points or depressions. Indeed, the researches of Broun and others, from a different point of view, strengthen this conclusion, which is, however, abundantly supported by a glance at the curves themselves; (2) the oscillations of the Trevandrum curve are greater than those of the Kew curve; (3) in many cases where there is a want of striking likeness between the oscillations of the two curves, there are yet noticeable traces in the one curve corresponding to the oscillations of the other. There are, however, a few cases where there is a want of apparent likeness. (4) In general, though not invariably, the oscillations of the Trevandrum curve follow rather than precede the corresponding oscillations of the Kew curve.

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Edison's Light.—The French specification of Mr. Edison has been published, but as it contains little more than we have been able to give our readers previously, we shall but glance at its salient points. The most important question is, what does Mr. Edison claim? and here is the answer:—1st, the combination with an electric light of a thermal circuit regulator, to lessen the electric action in the light when the maximum intensity has been attained, substantially as set forth; 2ndly, the combination with the electric light of a circuit closing lever, operated by heat from the electric current or from the light, and a shunt or short circuit to divert the current or a portion thereof from the light, substantially as set forth; 3rdly, the combination with the electric light and a resistance of a circuit closer operated by heat, and serving to place more or less resistance in the circuit of the electric light, substantially set forth; 4thly, the combination with an electric light of a diaphragm operated by the expansion of a gas or fluid in proportion to the temperature of the light to regulate the electric current substantially as set forth; 5thly, the combination with a vibrating body similar to a tuning fork of mechanism for maintaining the vibration, and magnets, cores, and helices, whereby a secondary current is set up, so as to convert mechanical motion into electric force, or the reverse, substantially as set forth; 6thly, the combination with electric lights, substantially such as described, of means for regulating the electric current to the same, in proportion to the heat evolved in the light, so as to prevent injury to the apparatus, substantially as set forth. The light itself is in all cases due to the incandescence of the body, and that the thermal regulator of the circuit is to be adjusted or made to act automatically to lessen the electric current before the same becomes sufficiently intense to injure the light-giving substance. This point will vary according to the material employed in the light. A cylinder of platina foil around a rod of lime gives an excellent light, and strips, wires, rods, beads, and pieces of iridium, ruthinum, rhodium, osmium, titanium, and other metals that fuse at a high temperature may be used. Also conducting oxides may be used, such as oxide of titanium. Mr. Edison prefers to have the light within a case or globe, and that various materials may be employed, such as alum water, between concentric cylinders to lessen radiation, retain the heat, and lessen the electric energy required; or coloured or opalescent glass, or solutions that reduce the refrangibility of the light, such as sulphate of quinine, may be employed to moderate the light, and the light may either be in the atmosphere or in a vacuum. The materials that he has found especially adapted to use as light-giving substances are named above. One of the methods adopted by Mr. Edison to regulate the current was given in our correspondence columns last week, and although various modifications of this arrangement are mentioned in the specification, it gives the essential features of the system. A rod expands in proportion to the heat developed by the passage of the current, and, if the heat becomes dangerously high, injury to the apparatus is prevented by the expansion of the rod moving a lever to close the circuit, and thus to short circuit or shunt a portion of the current from the incandescent coil, and reducing its temperature; this operation is automatic, and forms the principal feature of the invention, because it effectually preserves the apparatus from injury.

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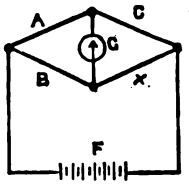
SENSITIVENESS OF WHEATSTONE'S BRIDGE.

Some difference of opinion prevails amongst electricians as to what constitutes the most sensitive arrangement of Wheatstone's Bridge for comparing electrical resistances. Now, were Wheatstone's Bridge little used, this would be of no importance; but as it has, on the other hand, most extensive employment, it is certainly desirable that the matter should be thoroughly threshed out. When it is considered that Wheatstone's Bridge is by no means a complicated electrical arrangement, and that the laws regulating the currents in the different branches, and the proportions in which they are divided when division takes place, are extremely simple, and their accuracy as well established as that of the law of gravitation, the wonder is that there should be any doubt respecting a question which can be brought under mathematical reasoning without any hypothetical assumptions whatever. In the following is given an outline of the subject, omitting all the algebraical work.

Wheatstone's Bridge consists of six conductors, A, B, C, X, F, and G, uniting four points. Let the small letters a, b, c, x, f, and g stand for their respective resistances. The property which gives so much value to the bridge in comparing resistances is that, if the following proportion holds, viz., $a : b :: c : x$, then an electromotive force in F causes no permanent current in G, or an E.M.F. in G causes no current in F. Thus, when there is an E.M.F. in F and no current resulting therefrom in G, we know that $a : b :: c : x$; and, therefore, if any three of these four quantities are known, the fourth can be found by "rule of three." Or, if $c : g :: f : b$, then an E.M.F. in A causes no current in X, and *vice versâ*. Or, if $a : g :: f : x$, an E.M.F. in B causes no current in C, and *vice versâ*. It is only necessary to consider the first case, viz., $a : b :: c : x$, making F and G conjugate.



Suppose X is a conductor whose resistance is to be determined, and that A, B, C are conductors whose resistances are known and adjustable. Also, F to be a battery and G a galvanometer. Then, to find x, we simply alter a, b, and c, or any of them, till the current in G is rendered inappreciable, and then we know that $x = \frac{bc}{a}$. Now, there is, theoretically, a doubly-infinite number of ways of doing this—of getting a balance. For, we have four quantities bound by two relations, viz., x constant and $a : b :: c : x$. Therefore, any two of the three conductors A, B, C may have any resistances we please for a balance.

As every one who has used the bridge knows, some arrangements—that is to say, some particular balances—are more sensitive than others. For instance, if a and b are extremely small, there is so little difference of potential between the terminals of the galvanometer that a want of sensitiveness arises that way. And, if a and b, are enormously large, the current from the battery is rendered very small, with a consequent want of sensitiveness. Now, if an operator can, by trial, easily find a sufficiently sensitive balance, and is satisfied with its sensitiveness, there is an end of the matter, and it is not worth while hunting after greater sensitiveness. But as it may happen that the greatest sensitiveness is desirable, or an approximation thereto, it becomes necessary to answer the question, What is the most sensitive balance? Unfortunately, this cannot be done without algebra, for there is probably no man living who could find it out in his head unassisted by symbols.

It becomes, in the first place, necessary to give a precise meaning to the word sensitiveness. If as nearly perfect a balance as possible be obtained, and then any one of a, b, c, x be altered by a given small fraction of itself—as, for instance, x changed to $x(1 + \Delta)$, where Δ is a small fraction—then a current will appear in G, of the same strength whichever one of the four be altered, though of opposite direction for b and c as compared with a and x. Obviously, one arrangement will be more sensitive than another if in the first the change of x to $x(1 + \Delta)$, or corresponding changes in a, b, or c, causes a greater current through the galvanometer than in the second. And the importance of an error is to be reckoned by the ratio it bears to the quantity measured; thus $\frac{\Delta x}{x} = \Delta$. Whence the balance of greatest sensitiveness is that one in which a given small change from x to $x(1 + \Delta)$ causes the greatest current through the galvanometer. For the greater this current the nearer can approximation to accuracy be made by adjustment, and if it is inappreciable, as in a coarse balance, no further accuracy can be reached.

It can be easily shown, for it is a simple consequence of the laws of the current, that if E is the E.M.F. of the battery and Γ the current through the galvanometer, that

$$\Gamma = \frac{E\frac{ax - bc}{s}}{\left\{\frac{(a+b)(c+x)}{s} + g\right\}\left\{\frac{(a+c)(b+x)}{s} + f\right\} - \left(\frac{ax - bc}{s}\right)^2},$$

where s signifies $a + b + c + x$. This is irrespective of a balance. Now let $a : b :: c : y$, and $x = y(1 + \Delta)$, and eliminate a. Then we shall have

$$\Gamma = \frac{E\frac{bc\Delta y}{s'}}{\left\{\frac{b(c+y)(c+x)}{s'} + g\right\}\left\{\frac{c(b+y)(b+x)}{s'} + f\right\} - \left(\frac{bc\Delta y}{s'}\right)^2},$$

where $s' = b(c + y) + y(c + x)$. When $\Delta = 0$, we have $y = x$, $\Gamma = 0$, and the perfect balance $a : b :: c : x$.

If now we give different values to b and c, say b' and c', then $\frac{\Gamma}{\Gamma'}$, where Γ' is the new current through the galvanometer, is the ratio of the sensitiveness of the first arrangement to the second. The expression for Γ' is the same as that for Γ with b changed into b' and c into c'. That $\frac{\Gamma}{\Gamma'}$ is the ratio of sensitiveness of the two arrangements will be true in the limit when $\Delta = 0$, *i.e.*, with an exact balance in each case. Therefore, dividing Γ by Γ', and *afterwards* making $y = x$ and $\Delta = 0$, we shall find

$$\frac{\Gamma}{\Gamma'} = \frac{\frac{bc}{\{b(c+x) + g(b+x)\}\{c(b+x) + f(c+x)\}}}{\frac{b'c'}{\{b'(c'+x) + g(b'+x)\}\{c'(b'+x) + f(c'+x)\}}}.$$

It follows from this that the *sensitiveness of any balance* whatever is proportional to

$$\frac{bc}{\{b(c+x) + g(b+x)\}\{c(b+x) + f(c+x)\}}.$$

The most sensitive balance can now be easily found by the ordinary rules of the differential calculus, treating b and c as independent variables. The result is

$$a = \sqrt{fg},\quad b = \sqrt{\frac{gx}{g+x}(g+f)},\quad c = \sqrt{\frac{fx}{f+x}(g+x)}. \quad \text{(A)}$$

The rule, therefore, is, for the most sensitive balance with a given galvanometer and battery. Make $a = \sqrt{fg}$. This is the same for all resistances to be measured. Find x approximately. Then make $b = \sqrt{\frac{gx}{g+x}(g+f)}$, or as near as may be convenient, and get the nearest possible balance by adjusting c. Then $x = \frac{bc}{a}$.

Having found the most sensitive balance, we are able to estimate the relative sensitiveness of any other balance, using the same battery and galvanometer. If ρ is the ratio of the sensitiveness of any balance $a : b :: c : x$ to the most sensitive balance possible (this may be called the ratio or coefficient of sensitiveness), then

$$\rho = \frac{(\sqrt{gx} + \sqrt{fx} + \sqrt{(f+x)(g+x)})^2}{\left(c + g + x + \frac{gx}{b}\right)\left(b + f + x + \frac{fx}{c}\right)}.$$

ρ is a quantity between 0 and 1, being 1 for the most sensitive balance.

A few numerical examples will serve to show the variation of the sensitiveness in different balances. Suppose $x = 4{,}000$, $g = 1{,}000$, $f = 90$ ohms. Then, in the following balances—

	a	b	c	x		
1.	1 :	1 ::	4,000 :	4,000,	we have	$\rho =$ ·003
2.	10 :	10 ::	4,000 :	4,000,	,,	$\rho =$ ·029
3.	100 :	100 ::	4,000 :	4,000,	,,	$\rho =$ ·24
4.	1,000 :	1,000 ::	4,000 :	4,000,	,,	$\rho =$ ·75
5.	10,000 :	10,000 ::	4,000 :	4,000,	,,	$\rho =$ ·38
6.	1 :	10 ::	400 :	4,000,	,,	$\rho =$ ·025
7.	10 :	100 ::	400 :	4,000,	,,	$\rho =$ ·219
8.	100 :	1,000 ::	400 :	4,000,	,,	$\rho =$ ·90
9.	1,000 :	10,000 ::	400 :	4,000,	,,	$\rho =$ ·58
10.	10 :	1 ::	40,000 :	4,000,	,,	$\rho =$ ·0024
11.	100 :	10 ::	40,000 :	4,000,	,,	$\rho =$ ·027
12.	1,000 :	100 ::	40,000 :	4,000,	,,	$\rho =$ ·14
13.	10,000 :	1,000 ::	40,000 :	4,000,	,,	$\rho =$ ·203
14.	100 :	1 ::	400,000 :	4,000,	,,	$\rho =$ ·0029
15.	1,000 :	10 ::	400,000 :	4,000,	,,	$\rho =$ ·015
16.	10,000 :	100 ::	400,000 :	4,000,	,,	$\rho =$ ·027
17.	300 :	1,800 ::	666⅔ :	4,000,	,,	$\rho = 1$ nearly.

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In the first five, we have equality between a and b, and the sensitiveness increases rapidly, reaches a maximum, and afterwards diminishes less rapidly. In the next four, $a : b :: 1 : 10$, and the sensitiveness is greater and behaves similarly. There is a falling off in sensitiveness in the following four, where $a : b :: 10 : 1$, and a great falling off in the next three, where $a : b :: 100 : 1$. Finally, No. 17 is nearly the most sensitive balance, and $\rho = 1$ nearly.

It does not follow that the most sensitive balance is also the most convenient. This is obviously the case when the resistances of the conductors A, B, C giving greatest sensitiveness are out of reach. Also, if balance be obtained by adjusting the resistance of C, and the least change that can be made in C is one ohm, it may be convenient to make the ratio of $a : b$ and $c : x = 10$. For, although there may be a loss of sensitiveness consequent on using this ratio, yet, since a change of one ohm in x then corresponds to a change of 10 ohms in c, x may be measured to a tenth of an ohm without calculation. But that any greater accuracy is attained by using the ratio 10 : 1 if the resistance of the conductor C can be altered by tenths or hundredths of an ohm, as by employing a divided wire with a sliding contact, or a duplicate arc, or other means, is a delusion; for the nearest approach to accuracy must finally depend on the least current recognisable in the galvanometer, and therefore on the sensitiveness.

I have given what I believe to be the most general way of estimating the sensitiveness of a balance with a certain galvanometer and battery. When special conditions are introduced, special results must follow. Thus, for example, if the sum of a and c is maintained constant, and also the sum of b and x, the most sensitive arrangement subject to these conditions is $a = c$, and $b = x$. And if the sum of a and b is kept constant, and also the sum of c and x, then the most sensitive balance is when $a = b$ and $c = x$. Further, if the sum of a, b, c and x is kept constant, then we shall have $a = b = c = x$.

Also, if a, b, c and x are separately kept constant, having any values producing an approximate balance, changing the places of the battery and galvanometer may produce benefit. The current in the galvanometer is increased or decreased by changing the positions of F and G according as $(g - f)(a - x)(b - c)$ is + or −. From this the rule follows for the best position for the galvanometer. Of the two, F and G, place the one of greater resistance so as to connect the junction of the two greatest consecutive resistances (out of A, B, C, X) with the junction of the two least. (By consecutive is meant that two resistances are next each other in the bridge. The two greatest resistances may not be consecutive.) This rule is always complied with when the most sensitive balance, $a : b :: c : x$, is used.

As to the galvanometer and battery resistances. If the space in a galvanometer to be filled with wire is constant, then it is well known that the size of the wire should be such as to make its resistance equal to the external resistance to get the greatest magnetic force. And, to produce the greatest current externally, a battery consisting of a number of similar cells should be arranged when possible in so many rows of so many cells each, as to make the internal and external resistances equal. Applying these principles to the balance, we have—

$$g = \frac{(a+b)(c+x)}{a+b+c+x}, \quad f = \frac{(a+c)(b+x)}{a+b+c+x}.$$

If, with these values of the battery and galvanometer resistances, we also employ the most sensitive balance, we shall find that the resistances of all the conductors should be equal, or

$$a = b = c = f = g = x.$$

This is absolutely the most sensitive balance if f and g can be varied in the manner stated, which is obviously impracticable in the vast majority of cases.

OLIVER HEAVISIDE.

THE VOLTAIC CAUTERY OF M. TROUVE.

It is well known that the passage of a voltaic current through a metallic conductor of small section is a means for raising the temperature of the latter to any required extent. According to Joule's law the heat produced in unit time is proportional, first, to the resistance that the wire opposes to the passage of electricity, and, secondly, to the square of the current passing.

This property of the current, by which it may heat to redness or even to whiteness a suitable metallic conductor, was utilised in surgery by John Marshall about 1851, by Leroy d'Etioles in 1853, by Middeldorpf in 1854, by Broca in 1856, and since that period by many others. Such a wire, when employed for cauterisation, is termed the galvano-thermal caustic. The cautery itself may take a variety of forms, some of which are shown in Fig. 1. To the left is shown the holder for the conducting stem, which is formed of two concentric conductors insulated from each other by fused porcelain, which does not, like ebonite or ivory, deteriorate by the effect of an elevated temperature. The conducting stem is here armed with a loop of platinum wire. To the right are shown the cauteries in most frequent use, viz., the knife cautery l, the needle cautery o, and the pointed cautery P.

Formerly, the nitric acid batteries of Grove and Bunsen were used for heating the cautery. These have now entirely given place to various others, formed of the bichromate of potash battery, invented by Poggendorff in 1854, and described by Du Moncel, two years subsequently, in his "Exposé des Applications de l'Electricité." The high electromotive force of this

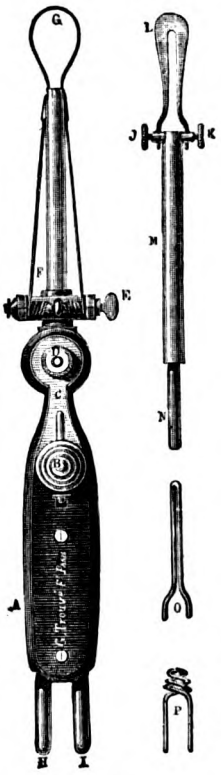

FIG. 1.

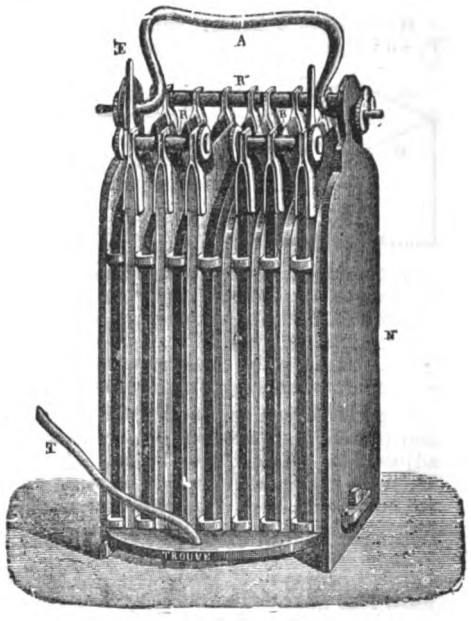

FIG. 2.

battery and the total absence of deleterious emanations were advantages in this battery which could scarcely fail to be appreciated; but, on the other hand, its want of constancy caused it to be practically ignored until the year 1858, when M. Grenet obtained with it results which attracted great attention. To him was due the happy idea of blowing air into the fluid contained in the cell, a device by which the battery was made much more constant in its effects in virtue of the fresh portions of fluid continually brought into contact with the negative plate.

The very convenient modification of Grenet's battery devised by M. Trouvé is represented by Fig. 2. In this arrangement the zinc and carbon elements are movable, so that the former can readily be amalgamated and the battery cleaned when necessary. The frame supporting the elements is formed of three plates of hard india-rubber, one of which is the base, whilst the others constitute the side-pieces. These are held together at the upper part by the handle which serves to raise the battery from its containing vessel. The elements are kept apart in the simplest manner by means of indiarubber bands.

In the figure N is one of the plates of hard rubber forming, with the base, the frame which supports the elements; A is the handle for raising the elements out of their containing vessel, which is also of hard rubber; R R R are moveable contacts; E is one of the rods to which the terminal conducting wires are attached; and T is the tube by means of which air may be blown into the exciting fluid.

The elements in this battery may be connected together in several ways, so as to vary, within certain limits, the electromotive force and the internal resistance.

STRAY NOTES ON SUBMARINE TELEGRAPH CABLES.

The first submarine telegraph across any length of sea ground was that laid on August 25th, 1850, between Dover and Cape Grisnez. It was laid from the London paddle tug Goliath.

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The wire consisted of a single solid No. 16 copper wire covered with gutta percha to a thickness of half an inch. The wire was wound on a drum made from a spar of wood. This was placed across the deck and the ends of the axle supported on two frames. The ends of the wire were encased in lead pipe for a few yards from the shore, and this formed the only "shore end." In order to moor this line lead weights in the shape of two flat squares, with a diagonal half groove in each, were rivetted on to the cable in pairs, a piece of warm sheet gutta percha being laid round the insulated wire to give it a little protection from the edges of the metal. The line was successfully paid out and signals were transmitted from shore to shore, but the line failed the day after, and it was said that a fisherman hooked it up and cut it through with his knife. Mr. Wollaston and Mr. W. Reid were the engineers for this line, which was laid to save the concession.

The first regular submarine cable was that between Dover and Sandgate, commonly called the Dover and Calais, which was laid September 21st, 1851. The cable consists of four conductors, each of No. 16 copper wire insulated with gutta percha to a thickness of No. 2 B.W. guage. A serving of Russian hemp saturated in Stockholm tar and tallow, and covered with ten galvanised iron wires of No. 1 guage, gave it a total weight of seven tons per statute mile. The cable was coiled on board an old paddle man of war, H.M.S. Blazer, which had had the engines and boilers removed, so that she was a mere hulk. There was no other break than a kind of squeezing nipper, and no wheels of any kind. The ship was towed by a tug. She broke adrift once, and drifted considerably before fresh hawsers could be laid out to the tug. This caused the cable to run short, and it had to be completed some days after, an additional piece having to be manufactured. Mr. Wollaston and Mr. Reid were the engineers, and Mr. Crampton the contractor. Mr. Newall made the cable at the works of Messrs. Wilkins and Weatherly.

This cable forms the first example of a telegraph cable with wires laid on by the untwisted wire rope process, which is adopted in some form in every cable, and, indeed, in so far as a compound cable—that is, a cable containing several conductors, it is not only the first example, but very little improvement has been made on its general design since. The changes in this type of cable consist in strand conductors, instead of solid wires, and made of purer copper wire, better insulating gutta percha, and the addition of yarn and asphalte outside to protect from oxidisation. The cables for such seas are also now made a little heavier.

The next cable laid was from Holyhead to Howth. It forms the first example of a single insulated wire covered with (No. 12) galvanised iron wires. It had no serving, and only weighed 10cwt. to the mile. It was laid by Mr. Newall, from the Britannia paddle steamer, on June 1st, 1852, and it soon after failed. On this line the drum break was first employed, which consists of a cast iron drum, generally six feet diameter, with a break strap acting on one portion of it. A piece of iron, called the knife or plough, is fitted so as to nearly touch the drum on the side, just above where the cable leads on to. The cable is taken three, four, or five turns round the drum, and the knife causes these turns to move sideways (or fleet in nautical language), so as to keep from getting under the portion that is leading on. Various improvements have been made on this arrangement, but the principle of the drum, knife, and a break strap remain. The knife has been improved in form, and is made with a hard steel face, as the cable, grinding against it with considerable force, soon cuts a groove in ordinary wrought or even cast iron. The knife is made to adjust so that it can be moved sideways to widen the space it clears on the drum, according to the type of cable being used. The drum is now also generally made with both the bearings of the shaft on one side of the drum, so as to allow of the turns of cable being taken off the drum, or an extra turn put on if required, when the end is not obtainable, which could not be done before, when the axle was supported on each side, without cutting the cable. The break strap has been varied in several ways. In the first breaks one end of the strap was fixed to the frame, and the other to the lever, the drum revolving so as to drag from the fixed point towards the lever. This is the most powerful break; but it has the disadvantage that the part near the fixed end does not easily free itself when it is desirable to take all break power suddenly off. In other cases both ends of the strap come to the lever; but this is not so powerful, as the pull tends to raise the lever, and slack the break. For this reason it is, perhaps, a little more adapted, where only a moderate strain is required, as it partakes somewhat of self-relieving character when the lever is weighted; but if the distance of the pulling end of the strap is far from the fulcrum, it may not be powerful enough to hold a heavy strain. Breaks so constructed, when the coefficient of friction between strap and drum has become reduced from any cause, have been found barely sufficient to hold the cable with several men on the straps, and in one case a gun had to be slung on to the break handle. There should be with this kind of break strap another independent break strap, with the pulling end fast to frame, as a stand by, in case of having to hold the cable at all costs to save life or limb.

The strap is sometimes made to bear directly on the iron, and in other cases blocks of wood are attached to it, and we thus have friction of wood against iron. The breaks have a constant stream of water playing on them to keep the drum cool. Great care has to be observed to keep all oil and grease from the breaks. In one case, when iron on iron was used, the drum was found to increase in speed, although more and more weight was added. It was at last detected from the change of sound that the drum was being lubricated, and finally it was discovered that the engineer had put the donkey engines that were pumping up the water for the break into the bilge instead of on to the sea, and the greasy bilge water thus pumped up, was lubricating the break.

THE SOCIETY OF TELEGRAPH ENGINEERS.

At the meeting on February 12th, Mr. Willoughby Smith read a paper on the subject of "The Working of Long Submarine Cables."

The President of the Society, Major Champain, briefly introduced the author of the paper, who said: He thought the subject he had to bring before the members would be interesting, and useful for purposes of reference. He had been induced to present this brief history, as there seemed to be a very considerable misapprehension existing as to how and when and why the present system of working cables was introduced. Having been personally and practically connected with the work ever since the laying of the first successful Atlantic cable the author was in a position to give accurate and authentic statements of what had occurred. He then referred to the defects when electro-magnets were used for working long aerial, subterraneous, or submarine circuits, especially that of residual magnetism. M. Jacobi introduced the "counter current" system. To overcome what he termed "the injurious effects of condensed magnetism," a polarisation battery was introduced into the circuit, so that the residual magnetism was destroyed by the secondary current. This battery was described, and the system illustrated. The author then referred to Mr. C. F. Varley's patent in 1860, "improvements in electrical telegraphs" in reference to long submarine lines, in which was suggested the use of polarising batteries, condensers, or induction plates as a substitute for the same. At the date of this patent Mr. Varley was electrician to the Atlantic Telegraph Company, and a few weeks previously had informed the Company that he thought it possible to insure eight or nine words a minute through an Atlantic cable.

On the 14th February, 1862, the author published in *The Electrician* [old series—ED.] the results of experiments on the "coil current," or "false discharge." He had shown that if a coil of gutta percha covered wire was connected with a battery, galvanometer, and key, the discharge was much in excess of the charge, and of an opposite character to that of the true discharge when the distant end was insulated, and that the difference was more marked when the wire was wound on an iron reel. In the December following Mr. Varley patented five different modes of working long cables by the aid of induction plates, induction coils, resistance coils, and an ingenious adaptation of the effects of the "false discharge." These systems were fully illustrated by excellent diagrams, and it would be impossible to adequately describe them here without such aid. It seems that neither of these systems has been practically used. On the 6th July, 1865, just before the starting of the cable expedition of that year, Messrs. Thomson and Varley conjointly patented "Improvements in Electric Telegraphs." These improvements consisted in what was known as the "Curb Key," a mechanical arrangement by means of which three or more currents of equal strength, but unequal duration, could, in quick succession, be alternately sent into the conductor. The cable not being laid that year, the "Curb Key" was not employed, and before the next year further improvements were made, arising out of suggestions of Mr. Willoughby Smith himself, which superseded the key altogether. Before starting on the expedition of 1866 he had matured his plans for a new system of testing and speaking while submerging the cable, the idea of which had suggested itself during the previous expedition. The practice had been to devote certain positions of each hour to certain tests, and to apply each test independently. Two tests are absolutely necessary during the submerging of a cable, one for insulation, the other for continuity of the conductor. By the method pursued, the insulation of the cable was not known during the last thirty minutes of each hour, so that if a fault passed overboard then, it might be two or three miles astern before it was known to exist.

(TO BE CONTINUED.)

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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A TELEGRAPH TO SOUTH AFRICA.

Recent events, which during the past few days have aroused England, and startled it from its ordinary calm, compel us to return to the discussion of this important question. There is, however, little to be said that has not been said before; but one thing we must insist upon is that on the Government falls the blame of our not being in an advanced condition to communicate directly with the African colonies. Eight months ago we pointed out the necessity of connecting South Africa with the telegraph systems of the world; and since then we have on various occasions criticised the routes by which such communication should be made. From time to time, three different routes have been advocated—one on the western coast, tapping the Brazilian cable at the Cape Verde islands, and skirting the west coast; another traversing the Continent by land from Egypt southwards; and the third connecting the Eastern Company's system from Aden to Madagascar, Zanzibar, Natal, and the Mauritius. The latter is, after all, the only practical plan, as we have more than once shown, and it is, then, to this that we again direct attention. The purchase of Suez Canal shares at a cost of four millions was received with acclamation by the country. But this was patriotism. The bringing of an Indian contingent to the Mediterranean, the occupation of Cyprus, the purchase of the Crown lands of Cyprus, were acts all viewed favourably by the country; and this was again termed patriotism. We are not politicians, and we are glad of it; for never yet have we seen the Government that can issue victorious from the logic of facts. While men's minds are heated with party warfare, popularity is all that is required. History having no sympathy with such considerations frequently dwells upon "what might have been." We have been accustomed to look upon our colonies as the most precious possessions of the Crown. Without them England is nothing, with them she is the mistress of the world. There our brothers and sisters work out the inevitable ascendancy of the Saxon race. The indomitable energy, the stubborn resolve to do or die, is shown daily on all these confines of civilisation. Should not the great central heart beat in unison with the arteries which feed it, even though these arteries be situated in the far off corners of the universe. Government after Government seems to forget that our Colonies are ourselves. Undue attention is paid to things which occur in places not at present belonging to the Empire, although it may be these actions in the far off future will have more or less influence upon the welfare of the nation. There is, however, one grand law depicted throughout the whole known history of this universe, which, so far as we are aware, differs from ordinary laws in having no exception, and it is that the strength of a nation depends upon its coherence, and not upon a fictitious and fluctuating extension without. It seems to us that statesmen of both parties have overlooked this law, and there has been, and is, no continued striving to knit and weld together the bonds which should bind in the strongest possible manner the mother country and her numerous colonies.

It so happens that the immediate necessity of instantaneous communication with South Africa is so overwhelmingly apparent that we have no need to dwell upon it. The military situation could hardly be worse; and it is a fact that even before the reverse to our arms was known in England, a colony may have been at the mercy of victorious savages. The action that occurred on the 21st of January was unknown in England before the 11th of February—nearly three weeks—and what has happened during that three weeks? We hope that the nation will speak plainly, and demand that, a mistake having been made, it should immediately be rectified.

We are in a position to state that the Eastern Telegraph Company, in conjunction with the Construction and Maintenance Company, offered to lay a cable from Aden to connect the South African Colonies with their system, and to have the cable in actual work before the end of this year. Had any stern necessity required the work to be hastened, in all probability the connection would have by this time been in a fair way of completion. The companies could not ask their shareholders to lay this cable at their own risk, but entered into negotiations with the various governments and colonies interested for a small but guaranteed support. A certain income was expected to be derived from ordinary commercial work and other sources, but this for some years

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to come can hardly be expected to be sufficient to induce capitalists to embark from one to two millions of capital in such an undertaking. Considering the immense advantages which would accrue to the Government, and the small sum they were asked to risk, we should hardly have suspected that the welfare of important colonies would have been shelved till a more convenient season.

This is not the way to increase the confidence of the colonies in the mother country. As events have happened, the fault of the Government is so palpable that in all probability some explanation will be required in Parliament. It must not be forgotten, however, that while military necessities are great, the value of telegraphic communication is not to be based on military utility. The telegraph is essentially a necessity of commercial life and growth, and it is more on these grounds that the Government ought not to have hesitated for one moment in aiding the means at the command of a comparatively young colony. The colonies must be cherished and fostered till there exists no question as to their power to run alone. They have on this question of telegraphic communication expressed a decided opinion, and have recorded their determination to aid it by means of subsidies; the obstinacy, however, of the home Government has for months been a stumbling block to progress, and is now likely to reap its reward.

Briefly, then, the necessity of telegraphic communication with the Cape has been but too well established by recent events. Months ago the companies above mentioned offered to lay the cables if the Government would guarantee a certain small annual sum for a few years, till trade was developed. The Government, instead of accepting this offer, have put off the consideration of the question, hoping that the situation at the Cape would assume a more pacific character. Unfortunately they have been rudely awakened, by an appalling calamity, from a condition of passive expectation to the real state of affairs—in which a ready means of communication would have been a safeguard which it is now almost impossible to overrate.

THE DEPUTATION TO THE COLONIAL SECRETARY. AN AFRICAN LAND LINE.

It is incumbent upon us to notice that a deputation asking the Government to grant a subsidy for a land telegraph line through Africa, had an interview with the Colonial Secretary, on Wednesday, the 12th February. The political statements made by the various speakers do not concern us, but the remarks made as to the route of telegraph communication are so absurdly inconsiderate that they must be mentioned. The daily papers, turning with every fluttering wind, without preliminary study, take up the cue and hasten to advocate an overland route. Will these gentlemen who say so much, and know so little, consider for a moment our actual knowledge of the African interior; will they take a map and note the hostile districts through which the wires must pass; will they advocate a series of military stations to protect the line through Central Africa; will they inform us how the line is to be made through forest, field, and swamp, over hills, and through districts where the testse fly reigns supreme, and where malaria strikes down almost every European that ventures on the ground. We are fully aware that Mr. Sivewright and others have advocated such a plan, but this simply shows how able men may be led astray. It is all very well to talk of the civilising work of the telegraph, but what is to happen before the consummation of that delectable time when the savage of Africa shall be civilised? You may civilise when your power is supreme, but to expect hostile tribes to respect telegraph wires or posts, is going a little too far. The safety of a land line would take as many years to guarantee as a cable would take days to be placed in excellent working order. One word as to the safety of the Aden-Zanzibar route. We have the steps Gibraltar, Malta, Cyprus, and Aden, from which to watch and protect the cable. In case of hostility the Mediterranean, Red Sea, and Indian Ocean, would be of all places in the world those in which our ships and men would be found, whereas any state with a couple of rotten ships could destroy the Atlantic cable with little difficulty, and little danger of detection. The latter, if cut, would be difficult of repair. The Aden-Zanzibar cable would present little or no trouble to restore, even if the unlikely event of its being cut occurred.

CORRESPONDENCE.

AUTOMATIC CURRENT REGULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 1st I noticed an extract from the "Comptes Rendus de l'Académie des Sciences," concerning an automatic current regulator by M. Hospitalier.

Now, I, having made a course of experiments on the electric light, particularly on light by incandescence, have devised two different automatic current regulators, both of which are efficient; one especially for light by the incandescence of wire, the other for the regulation of currents in general. The latter of these two regulators closely resembles that of M. Hospitalier, being, however, in my opinion, somewhat more simple. Both of these regulators were made by me in October last, and since then have been in constant use. I have hitherto refrained from giving any public account of them, thinking that the same principle must have been applied to this purpose by many electricians long ago; however, by the extract above alluded to, I see that a similar thing to my second regulator is spoken of as something new. In the hope, therefore, that others better versed in science than myself may perfect what I have begun, I shall, with your permission, give an account in your columns of both instruments, which it will be evident it is not my intention to protect in any way, be they original or not. By reference to the figure (Fig. 1) it will be at once seen that what is there represented is both a regulator and lamp combined.

A A′ are two triangular flat pieces of any hard wood, A has a hole bored in the centre, and another a little on one side; A′, which is the upper piece, and is considerably smaller and thinner than A has one hole only at its centre. A′ is fastened to A by three iron wire pillars, one of which being behind the rod B is not shown in the figure. A is supported from the ground by three wooden legs. B is a rod of any metal which is a good conductor of heat; the one made by me is of silver, tapped with a fine screw thread at the top, which passes through A′, and is supported there by the thumbscrew D. In order to give D and consequently B electrical connection with the small binding screw F under A′, B passes through a piece of thin copper on which the thumbscrew D rests, not shown in the figure, and soldered to the screwed end of the binding screw F, which comes through to the upper side of A′. The rod B also passes through A in the centre, and after passing a short distance below is sharply bent round so as to reascend immediately below the second hole in A, where it terminates in a small piston which fits a piece of tube C of wood or preferably vulcanite (glass is apt to crack with the heat disengaged by the current), firmly fixed into the second hole in A, part of the tube being above and part below A. The tube C is filled with specially prepared lamp black or with another substance still more susceptible of variable resistance under pressure, and of which I shall speak hereafter when describing my second instrument. The top of C is closed by a plug of brass screwed in, carrying on its top a small binding screw from which a wire runs to the main binding screw E. The rod B slides easily through its holes in A and A′. To F is fastened a coil of fine platinum or iridium wire, so arranged round B as not to touch it, and fastened at the bottom to a strip of copper which makes connection with E′, the other main binding screw.

It will be seen that by moving the thumbscrew D any degree

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of pressure may be exerted on the material contained in the tube C, and by means of this the wire may be brought to any heat; and this once being adjusted, any increase of current, passing in at E, through C, up through B, and descending through the platinum coil, will, by increasing the heat of that coil, also increase the heat of the rod B, which it surrounds, and this rod will be slightly elongated, which will correspondingly take the pressure off the material in the tube, and the increase in the main current will thereby be checked. Should a decrease in the main current occur, of course the opposite effect will be produced. There is some little difficulty in winding the fine platinum coil closely round B without actually touching it. An opal or ground glass globe may enclose the whole. It will be obvious that when once adjusted no readjustment will be necessary when working with the same machine or battery.

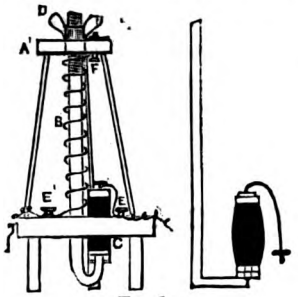

FIG. 1.

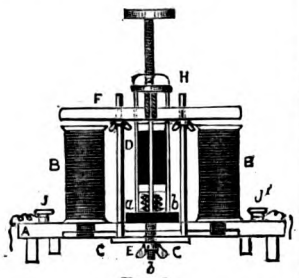

FIG. 2.

On reference to Fig. 2 it will at once be seen that what is there represented is of entirely different construction from Fig. 1, depending, as it does, on an electro-magnet for its action.

A is a square piece of flat mahogany of sufficient thickness, standing on four legs. B B′ is an electro-magnet, fastened to the wood as follows; two round iron rods are tapped at one end and at a suitable distance apart screwed through the wood and into a flat piece of iron, C, which is let into the wood on its lower side and tightened up by the screwed end of the two rods, which are thereby connected, forming, when suitable bobbins wound with silk-covered wire are put on the upright iron rods, an electro-magnet of horseshoe form. D is a wooden or vulcanite tube, which stands on a thin piece of brass, *a*, placed on the mahogany board, midway between B and B′. This piece of brass, *a*, has a smooth hole bored through it, the intervening wood, and the back, C, of the electro-magnet. This hole also continues through E, a cross piece of brass immediately below C, to which are soldered two upright brass pillars, which latter pass back by smooth holes through C, and the wood, but clear the strip of brass, *a*, on which the tube rests, continuing upward to F the armature of B B′, which they pass through, and support at any distance above B B′ by means of the nuts screwed on them under F. By means of the central hole before referred to, a rod of brass, *b*, tapped with a fine screw thread, passes smoothly through E, C, the wood and *a*, and ascends into the tube, where it terminates in a piston, exactly fitting the tube, between which and *a* the rod *b* is surrounded by a spiral spring of steel. On the lower side of E, *b* is secured by means of the thumbscrew *c*, which thereby causes E to support the armature F. By means of the thumbscrew, *c*, any pressure may be put on the spiral spring, and thereby taken off the material in the tube. This tube, D, passes through the armature F, and is headed by a brass cap, H, fastened firmly, and held by two brass pillars, one on either side, which proceed downwards to the board, where they clear *a*, or pass through wide holes, so as to be electrically insulated from it, and are firmly screwed into the wood; one only of these pillars is shown in the figure, the other being behind the tube. By these pillars, which pass through a projection of the cap on either side, and the nuts which they bear, H is held perfectly firm when a considerable strain is put on it. Another rod of brass finely tapped, and terminating in a milled head, is screwed through the centre of the cap H and proceeds down the tube D to a second piston of brass, fitting the tube, on which it presses, but to which it is not united. The figure is shown partly in section, in order to facilitate explanation. The material placed between the two pistons is rabbit wool, so much used by ladies for knitting, torn into shreds, and thoroughly imbued with pure black lead. In making a mixture of any two substances, the chief desideratum of the non-conducting material is that it shall be sufficiently springy to return to its original dimensions on the withdrawal of the pressure which has been exerted on it; having tried a number of materials for this purpose, amongst others wool, cotton wool, silk, and various sorts of fine fur, I have found rabbit wool best to fulfil the before-mentioned desideratum.

Prepared lamp black, as used by Professor Edison, or finely powdered carbon, answer very well for a time, but gradually lose their power of rebound.

In order to make the regulator suitable for any kind of current it is desirable to keep two or three sets of bobbins for the electro-magnet, wound with different size wires. It is well known that up to a certain mean point any increase of current produces a more than equivalent increase of magnetism, and, after this point is reached, a progressively less than equivalent increase. It is well, therefore, to keep the magnet as near as possible to this point in order to get the best results, and this may be done by altering the size of wire for different currents.

Connection is made by one of the pillars which support the cap, H, and a strip of copper with one of the main binding screws, J. The other binding screw, J′, is connected with one end of the wire on the electro-magnet bobbins, the other end passes to the next bobbin, the remaining end of which is fastened under *a* so as to make connection with it.

Let us say that the current enters at J, it then passes to the cap H, thence to the rod I, which is screwed into the cap, and from this to the upper piston and through the compressible material, offering a varying resistance, it thus reaches the other piston, passes down through the rod *b* to the piece of brass *a* on which the tube stands, and from this traverses the coils of the electro-magnets, and reaches the other binding screw, J′.

It will readily be seen that any increase of current, by increasing the power of the magnet, which will pull the armature correspondingly, will exert more pressure on the spiral spring round *b*, and take away pressure from the compressible material in the tube which will immediately let through less current by offering a higher resistance. If the current become weaker, the spring will be allowed to exert more pressure on the material in the tube, which will immediately offer less resistance, and more current will pass in consequence.

This regulator may be used for almost any purpose, and may be used with electric lamps branched from a main on which the automatic regulator is put. If only one lamp is put on, however, the regulator is apt to fight with it, precisely as two lamps do when coupled up in series. As all lamps, however, are, more or less, regulators themselves, it is questionable whether any advantage is gained by this. For electric engines I think it would be invaluable.*

In conclusion, let me say that, having only for a year made electricity and magnetism my special study, I am as yet a mere tyro in the science, and hope, therefore, that any mistakes which I have made will be viewed leniently by those who are older and wiser than, yours faithfully, J. WILLIAM GIFFORD.

Passlands House, Chard, Feb. 4, 1879.

(Translation.)

THE VOLTAIC PENCIL.

(LE CRAYON VOLTAÏQUE.)

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Since your estimable paper made known the results I had obtained with my *crayon voltaïque*, I have been made aware that several communications relating to analagous work have been published, particularly in English papers.

Having found in the well-known perforating power of the induction spark a very simple means of obtaining stencils analagous to those mechanically produced by the electric pen of Edison, I have no intention of denying that the same simple idea may have occurred to many electricians at an earlier period; but its application could be rendered practical only in consequence of results which allowed me to carry out numerous experimental trials, with the aid and co-operation of M. Hallez d'Arros.

We have thought it well not as yet to publish the details of the arrangements we have adopted to render this process really practical, and to allow of its economical employment. These arrangements constitute conditions which are indispensable in order that our *crayon voltaïque* may receive an industrial application.

The Electrician published, on the 25th December last, a communication from Mr. Lascelles Scott,† on the use of an "electric pen," which he recommends as capable of advantageously replacing the "Edison pen;" but, although this article has all the

* Where either of the regulators are to be used for very intense currents, such as are required for the electric light in fair-sized lamps, the tube must be made from 1in. to 1½in. in width; or the wool will, owing to its small quantity and high resistance, be burnt, and nothing but disappointment will ensue. The top screw, I, may be used as a valve for turning the current on and off, or may be dispensed with, and the upper piston omitted.

† The MS. sent by this correspondent was in our possession for several weeks before we published it. As it was forwarded to us in the form of a registered letter, the exact date of its transmission could, no doubt, be ascertained.—ED. *E.*

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appearance of a paraphrase of the note published by *Nature*, on the 21st November, on my invention, it could not contain any information, as yet unpublished, as to the arrangements which allowed us to obtain, by the use of the *crayon voltaïque*, the results which have been made known.

We were, therefore, not surprised to read in *The Electrician* of January 18 a letter in which one of your readers protests against the possibility of obtaining a practical result by the process of Mr. Lascelles Scott. Mr. Pumphrey, of Birmingham, says, "The faults I find with it are, that the sparks are not as continuous as is desirable, and they do not take *the* line of the pen, as the sparks deviate to the right and the left of the true line."

In order to reply to these objections, we think it well to forward to you a paniconographic *cliché*, obtained by the direct transfer upon zinc of a stencil made with our *crayon voltaïque*.

The Electrician also publishes, in a recent number, a letter from Mr. Garratt, who says that one of his friends invented, six months ago, an apparatus analagous to that recommended by Mr. Lascelles Scott. It is a pity that this friend of Mr. Garratt did not think fit at the time to initiate the public into the results of his work; but we doubt that these would have been of such a nature as to allow him now to dispute the priority of our process.

I hope, sir, shortly to be in a position to communicate to you, with a diagram and explanatory sketches, a complete description of the arrangements we have adopted in the construction of our apparatus.

The type model of the apparatus constituting the *crayon voltaïque* is already definitively adopted, and a large number of the instruments is about to be made, so that these will shortly be at the disposal of the public. The price, which as yet has not been decided upon, will be sufficiently low to bring this useful process within the reach of all who can profit by it.

I shall be obliged, sir, if you will be good enough to insert this letter, should you think it of sufficient interest, in the columns of your esteemed paper.—Yours, &c., L. BELLET.

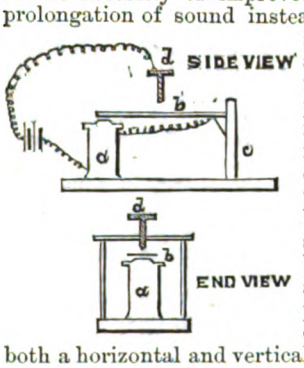
148, Rue Montmartre.

[We have received from M. Bellet several artistic impressions reproducing drawings made with the *crayon voltaïque*. These can be seen by any of our readers interested in the process.—ED. *E.*]

IMPROVED SOUNDERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of January 11th you draw attention to the necessity of improved sounders, advocating reading by prolongation of sound instead of, as at present, by intervals of silence. I beg to enclose sketch of a very simple arrangement on the make and break principle which appears to answer the purpose very fairly. *a* is an ordinary electro-magnet, with small core, *b* a piece of Ferrotype plate about one inch wide and three inches long, supported by an upright, *c*. *d* is an adjustable screw, with a fine point, supported by a cross piece, to enable it to be slid along the centre of the Ferrotype plate (from which, of course, the lacquer has been scraped off), ensuring both a horizontal and vertical adjustment. The sound is certainly not very musical, but would, doubtless, be improved if a thin steel vibrator were used in place of the Ferrotype. The vibrations do not split or break up the Morse characters when used in circuit with an inker.—Yours, &c., W. B.



THE ELECTRIC LIGHT IN COAL MINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to a Note in your issue of Jan. 18, I claim, in virtue of my French patent of 1874 and my Belgian patent of the same date, the first idea of "the use of electricity as a means of lighting coal mines;" and I may add that this means can be carried into effect only by the use of my perfected apparatus for avoiding all danger of the explosion of fire-damp.

Pray bring this communication to the knowledge of your readers, for the sake of the interests of humanity,* as well as with a view to the progress of mining industry.—Yours, &c.,

A. B. BOULLENOT, Senior,

Chemist and Inventor of La Lampe Antoxyde Electrique.

* Recent explosions of Dinas in the Rhonnda Valley (near Cardiff), and those of the coal works of Coffin and Co. at Pandy.

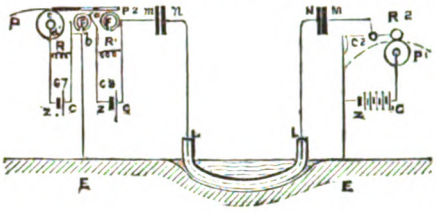
SPLIT AND TUBULAR ARMATURES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit me to call your attention to a diagram illustrative of a novel system of soft iron split tubular armatures, with soft iron split tubular magnets (in combination with Cromwell F. Varley's system of condensers) for the fast automatic transmission of telegrams on *ocean cables* of any length. This communication may interest many readers of your journal.

It has been asserted by "eminent electricians" that an automatic reception of signals on very long submarine lines cannot be accomplished by any arrangement of armatures, or other apparatus which moves at a fixed strength of current, but requires some arrangement which shall be capable of following and indicating or recording every change in strength of the received current.

By the use of "*Polarised relays*" and the ordinary "*Morse relay*," with or without retractile springs, the above assertion has been verified. I will proceed to describe my arrangement of apparatus for obviating such difficulties, whereby submarine lines of any length may be practically worked so as to record "*dot and dash characters*" up to a speed many times greater than by any



means heretofore known; and, to show the power developed by my apparatus from a very small current, allow me here to remark that instruments constructed in accordance with the above diagram were also worked *(without condensers)* as very correct and noisy *direct sounders* between the Cities of Charleston, S.C., and New York, along the South *Atlantic Coast* on over eleven hundred miles of line, including *four cables*, when the tongue of a *Polarised relay*, and that of a very delicate *Morse relay* with a "*retractile spring*" would not respond.

In the diagram F and F^1 represent a soft iron split tubular *Electro-magnet*, with a balanced soft iron split tubular armature and *stylus* F^2, 67 and 68, each a single constant element, R and R^1 adjustable *rheostats*, C^1 a metal drum for the paper strip, *a* and a^1 conductors for completing the circuit through the paper strip when the instrument is used as a *Chemical recorder*. If used as an *Ink-writer a* and a^1 should be united, *a* being a branch or fork to F from *b*.

The instrument is operated by causing the contact roller R^2 to make connexion by way of the drum C with the copper pole of the battery, when a rise of potential will take place through the cable L L, brought about by induction from the condenser at M. The rise of current from N to *n* causes a small flow from *m*, *neutralising* the constant in F^1, *energising* F, and slowly passing to earth E, causing thereby the stylus F^2 to be firmly pressed on the paper strip, the duration of which is controlled by the arm and earth spring C^2 being brought into contact by the thickness of the perforated paper lifting the roller R^2, which allows a sudden fall in the current to take place at *m*, the stylus F^2 being immediately lifted from the paper by F^1, the constant 68 accelerating the operation, or to speak practically, allows the current between N and *n* (no part of which leaves the cable unless by induction) to suddenly come to its *normal* state at longer or shorter intervals of time, by contact at C^2 with the earth wire E effected by the movement of the perforated strip P^1, or a Morse key at R^2, the constant at 68 simultaneously neutralising what is left of the small flow from *m*, through F and F^1 to earth E. If a zinc current is used at the transmitting end, it will be understood that the constants 67 and 68 must also be reversed; in either case F^2 will operate as an ink-writer, so as to record *uniform* dots and dashes.—Yours, &c., GEO. LITTLE.

Rosedale, Richmond, Virginia, U.S.A., January, 1879.

THE FAR WEST.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Thinking it might be of some interest to your readers to know what is being done in the Far West in electrical matters prompts me to write a few lines. Our city is distinguished in a few electrical matters. It was the early home of the celebrated sculptor, Hiram Powers, who while here was somewhat of an electrician. In an old museum now gone, and only remembered by old citizens, was a representation of the infernal regions, with his satanic majesty and lesser gods modelled in wax by Powers.

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To make the same more infernal and horrible he constructed an induction coil. When all the uninitiated were holding on to the iron railing which kept them back, and which was in electrical connection, he suddenly threw his current through the railing. The effect was grand and sublime, and many victims to this day have not forgotten Powers and his infernal regions. It was a success. Professor Locke, now dead many years, constructed one of the first electrical controlling clocks ever made. In this city the weather report system was first planned by some employés of the Western Union Telegraph Company and Cleveland Abbey, now of the Signal Service Bureau at Washington. In looking over your paper I have been surprised at the slowness of the employment of the Bell telephone in England. I had the honour of bringing to this city the first telephone of any kind in August, 1877. It was immediately introduced on private lines with success. Last September the Bell Telephonic Exchange was started here, and now it is in full operation and doing splendid service. The enclosed daily paper contains a full account of it, with the list of subscribers to date. One of our best educated and most talented electricians, Dr. L. R. Longworth, died last week. His lectures and experiments on the electric light and telephone proved him an original and enthusiastic thinker and worker. He was young, and his loss is keenly felt. We have an Electrical Society here. It meets monthly. It is promising and doing well, and its members are keeping up with all new inventions and improvements. We all are comparatively young in the science and art. Could we but attend one meeting of your grand Society of Telegraph Engineers, and see and hear Tyndall, Huxley, Siemens, Thomson, Clark, Sabine, Preece, Abel, and other distinguished electricians, our enthusiasm would know no bounds. By the way, I think the telephone was known and used B.C. 540. The followers of Pythagoras said that he could be present with and address his students in several different places at the same time. As the maxim of his philosophy was "not unto all should all be made known," we are not informed as to his method. But I surmise that he did it by means of the telephone. The largest magnet ever made must have been in the Serapion of Alexandria, for it is said to have held suspended in the air near the ceiling a car with four horses. In comparison with this, the magnets that suspended Mohammet's coffin pale into insignificance.—Yours, &c.,

J. O. SHIRAS.

Cincinnati, Ohio, U.S.A., Jan. 20, 1879.

EXPLANATIONS WANTED.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Even a few months' old electrician (as I am), should, I think, constitute himself a detective, and try and find out what electricity is and does. I, therefore, submit the following queries to you:—

1. The "fluids" are on the surfaces of a Leyden jar, the *portable cases* are free from the slightest charge. How is it, then, that the tongs applied to the *cases* instantly discharge the jar?

2. How is it that there is no limit to the discharge of the negative of a positive conductor (of course, the machine is kept going)? One would think if the conductor was electricity itself instead of metal it would have a limit. So also of the gold fish (?) which is so very small.

3. If the leaves of the electroscope are not repelled, but attracted by external induced electricity, what causes the positive on the outside of a Leyden jar (positively charged) to quit. One would think the negative would hold it captive as the internal position holds it.

4. If electricity can be carried away from the poles of a battery *ad infinitum* without any change in the elements of the battery, what becomes of the doctrine that the burning of the zinc produces the electricity, or that electricity cannot be had for nothing?

Sir, If there is nothing in these questions, pray don't allow your kindness to give yourself any trouble to notice them.—Yours, &c.,

THOS. METCALFE.

Jan. 30, 1879.

THE ELECTRIC LIGHT.*

By WILLIAM HENRY PREECE, M.I.C.E., V.P. Soc. T.E.,
Electrician General Post Office.

(CONTINUED FROM PAGE 137.)

Now, in all substances which we use for the production of light, we have a combination of hydrogen and carbon brought into contact with the oxygen of the air. In the first instance heat is applied to the wick, or to the escaping gas, and we produce, first, a separation of the hydrogen and carbon, and then a combination of the hydrogen and oxygen of the air, which produces water and greater heat, and this greater heat renders incandescent the carbon particles which have been set free, and which combining with oxygen form carbonic acid. The products of combustion are thus, in all cases, water and carbonic acid, but, in the case of poor gas, there are certain impurities set free, such as sulphuretted hydrogen, difficult to remove.

In estimating the value of a light, it is necessary to have some standard by which that light can be compared. In England, the standard light has been defined by Parliament to be that of a sperm candle, of six to the pound, consuming 120 grains per hour. Compared with this standard, a Carcel lamp gives 9·3 candles, the ordinary street lamps of London give 12 candles, a good Argand burner gives 20 candles, the oxy-hydrogen light gives 200 candles, and the splendid 6-wick lamp, used by the Trinity House authorities in our lighthouses, gives 722 candles. There is no doubt that this is a very convenient standard to work by, and it is as useful in comparing light as the foot or the gallon in their respective uses. One cubic foot of gas consumed per hour gives a light-power of 3·5 candles, but the light-power per cubic foot consumed increases with the amount of gas consumed at the same time. For instance, if 111 cubic feet of gas be burned per hour, we get a light equal to 500 candles, in which the unit power is raised to 4·5, *i.e.*, in such a burner each cubic foot of gas gives 4·5 candle power.

It is worth knowing that every human being vitiates 3,000 cubic feet of air per hour, and each gas jet, burning 3½ cubic feet per hour, vitiates 5,000 cubic feet of air, and it is interesting to compare, in this respect, the different materials used, which are shown in the following table, and to which has been added the relative cost of production:—

Material.	Carbonic acid, cub. ft.	Heat.	Relative cost.
Gas.....	4	32	1
Oil	6·4	63	7·1
Tallow candles...	10·1	100	10·0
Wax	8·3	82	30·0

From this table it will be noticed, perhaps to the surprise of some, that in every respect, whether we regard cost, carbonic acid produced, or heat-evolved, gas is very much superior to any other form of luminant.

Light being merely due to matter being raised to a high temperature, it follows that the best light is that which concentrates the greatest amount of heat on the smallest quantity of matter. If, for instance, 1,000 red-hot pokers were brought into this hall, we should not be able to see each other by their means, but if the heat distributed upon those pokers were concentrated on a pill, we should have a light which would outvie the electric light. From this it follows that, to produce the electric light, we must first produce heat, and, secondly, we must supply matter. Now heat, light, and electricity, being mere forms of energy, it must, according to the laws of energy, be absolutely essential, before we can produce those effects, to have the energy in some other form, in some other place, to be converted into those forms. In practice, there are two modes by which this is done. First, the potential energy of zinc is converted in an ordinary galvanic battery, first into electricity, then into heat and light; or, second, the potential energy of coal is converted in a furnace into steam, then, by the agency of an engine into motion, thence into electricity, and, lastly, into heat and light. We will describe each of these modes.

First, the battery. Here zinc is consumed in a voltaic cell, and in its consumption it gives out an amount of energy which appears in the shape of an electric current. This electric current can be reproduced as light either by rendering a fixed wire incandescent or by leaping across an air space, carrying with it small particles of carbon which are rendered incandescent through the violent temperature that they assume. The latter mode is called the electric arc, and it was discovered by Sir Humphrey Davy, in 1808, by means of 2,000 cells, which were supplied to him through the liberality of the members of the Royal Institution. In 1843 Grove produced his marvellous battery, which was able to produce as great effects with sixty or seventy cells as Davy produced with his enormous battery. In 1843 Sir William Grove used fifty cells to produce a light equal to nearly 1,500 candles, and by this means was able to illuminate the hall of the London Institution. In 1846 our Parisian friends used it for illuminating the stage of the French Opera House, and no one has visited or listened to the lectures at the Royal Institution without finding such a light occasionally used for illustrating the lectures. The use of a battery for the production of light is, however, attended with difficulty; it is troublesome to maintain in action for more than an hour, and the

* Lecture at the United Service Institute.

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materials it consumes are expensive. Hence, the electric light produced by the battery has never been of practical value.

The second source of electricity is coal consumed in a furnace. In the year 1831, Faraday showed how it was possible to convert mere motion into electricity when this motion was imparted to a coil of wire in the neighbourhood of a magnet. Energy is always consumed when work is done. It is always consumed when any resistance is overcome. When we move about we overcome the resistance of gravity. When a wire is moved in the neighbourhood of a magnet, we overcome the resistance due to magnetic attraction. In the first case we experience heat in our bodies, in the second case we experience electricity in the coil; and when we move such a coil by means of our arms we directly convert the muscular energy of our arms into the electric current. Pixii, in 1832, Saxton, in 1833, and Clark, in 1834, took advantage of this discovery of Faraday to construct machines in which currents of electricity were produced either by the rotation of coils in the front of a magnet, or by the rotation of a magnet in front of coils; but it was only in 1856 that Professor Holmes produced powerful uniform and continuous currents always flowing in the same direction, which were of sufficient strength to produce the electric light. He was assisted in his labours by the great Faraday, and is certainly the father of lighthouse illumination by electricity. His apparatus was shown at the International Exhibition of 1862, and it was practically established at Dungeness in the same year for the illumination of that lighthouse. Holmes's machine was dependent upon the motion of coils of wire in the field of a powerful permanent magnet. A company was formed in France for the production of the electric light by means of Holmes's machine. This company was called the Alliance Company, and Holmes's machine is known in France as the Alliance machine. In this case the energy of the coal consumed in the furnace, which was converted into steam and then into motion, became, by the resistance overcome in the magnetic field, powerful currents of electricity; but the proportion of energy transformed into electricity was a very small portion of that consumed in the furnace; indeed, in the very best steam engines only a small fraction of the energy is utilized, and there remains great room for improvement in the utilization of that fraction of the energy which is found in the steam engine. In the very best steam engine, consuming from three to four lbs. of coal per horse-power per hour, scarcely one-tenth of the energy is utilised, and it is a matter of great consideration to make the best use of this fraction of the energy of the coal.

(TO BE CONTINUED.)

ANGLO-AMERICAN TELEGRAPH COMPANY, LIMITED.

The half-yearly general meeting of the shareholders of this Company was held on Friday, the 7th of February, at the Cannon-street Terminus Hotel, under the presidency of Viscount Monck, the Chairman of the Board of Directors.

Mr. John Grant (the Secretary) having read the advertisement convening the meeting; the report was taken as read.

The noble CHAIRMAN, in moving the adoption of the report, and the payment of the dividend therein recommended, said there had recently been frequent, though not uncalled-for, lamentations about the depression of trade. Although he could not reveal any great improvement in the commercial transactions of the country, he had the satisfaction of telling them that the Company's traffic had not materially suffered from the depression, although it would have been larger if it had not existed. It had not, however, prevented a continuous and growing increase in the revenue of the Company. They had frequently had to change their tariff for messages to America. They had been now working on a uniform tariff for some time, and, from the best opinions they could form on a comparison of the figures of the three half years, the Company's revenue had given a natural increase of from 5 to 7 per cent. This was very encouraging, particularly bearing in mind the depression which had prevailed in all commercial enterprises; and he thought they might reckon, with something like certainty, that, whatever the increase had been, it would be larger when the depression had passed away. At the last half-yearly meeting a wish was expressed that the accounts should be shown in more detail than they had been in the habit of giving them. The directors regarded themselves simply as trustees for the shareholders, and were anxious to give them every information. They also desired their criticism on the accounts and the Company's transactions, because it strengthened their hands. The form of the accounts was identically the same as before for the purposes of comparison, but they had appended to them a detailed statement, showing what items each of the figures in the general report was composed of. In this way they enabled the proprietors to make a comparison from year to year, from the beginning of the Company, of their accounts, and the details also enabled them to make any remarks on them which they might consider necessary. In their report they alluded to the failure of the expedition which was sent out last year to repair the 1866 cable. This matter was put into the report merely *pro formâ*, because he informed them of the failure at their last half-yearly meeting. That, no doubt, was a strong warning to them in respect to another matter, and he thought it was so regarded at their last meeting—he referred to the laying by of an adequate sum for a renewal account. The directors had been doing so, and were very happy to be able to do so without reducing the dividend to an excessive extent. They were in great hopes—but he had expressed this hope before—that the time would come when the normal increase of their traffic would enable them to pay a larger dividend. It would be most agreeable for the directors to do so, for there was nothing less satisfactory than to have shareholders coming and saying that they were not getting an adequate return for the capital embarked in the enterprise. He desired particularly to draw their attention to the proposed superannuation fund for their officers, because it was a new source of expenditure. All the great employers of labour, from the State downwards, had found it necessary to make some provision independently of a man's own exertions for his old age or his being obliged to retire from illness or any such cause. It would give them a very strong hold over their servants during the period of their service. There was a peculiar reason why, in this Company, they should make some provision like that which was now proposed. He did not know whether any of them had seen the mirror system of telegraphy, which was that by which they communicated with America. If they had not, he advised them to do so, for it was one of the most ingenious and beautiful pieces of machinery he had ever beheld; but it involved the continual watching of a small speck of light revolving over a diagram. This was so great a strain on the eyesight, that after some years a man became almost incapable of earning his living by any other mode of occupation. It was not proposed that the Company should pay the whole of the superannuation; the officers would themselves subscribe half. He trusted that the proprietors would sanction the proposal on the grounds he had mentioned. He was informed by their legal adviser that the directors had the power of making this provision without bringing it formally before the meeting, but they preferred to do the thing openly, and to take the sense of the shareholders on it. There was one other matter which he thought it was necessary to allude to. It was in respect to what was pretty well known, and therefore it would be childish to pass it over—in respect to the new company which was supposed to be starting in hostility to this Company. He had no doubt that many of them had seen in the Money Article of the leading journal yesterday morning a statement from Paris, which he took leave to say was written with the view of what was called forcing the hands of the directors at the meeting that day. One of the statements was that the caution money was paid, but the fact was that the caution money in the company had not been paid at all. All that he had to say on the subject was that the directors were fully alive to the importance of any attempt of this kind. They had taken, and were taking, every means in their power to protect the shareholders' interests, and he trusted that they would have sufficient confidence in the board to leave the matter in their hands, and not play the game of the enemy by forcing them into premature disclosures. In conclusion, he congratulated them on the state of their property. The cables were working well, and the French cable, which had now been in the water for nearly ten years, was, he was informed, in better condition for working than at the beginning. The other cables were in excellent condition. The traffic was prospering, and he trusted they would be relieved from any fears of interference from any quarter with the prosperity of the Company.

Captain A. T. HAMILTON, the Deputy-Chairman, having seconded the motion,

A discussion followed, in which Mr. Jackson and several other shareholders took part, the former gentleman regarding the failure in connection with the repairs of the 1866 cable as a heavy discouragement to enterprise in submarine telegraphy. The other speakers held that the expenses were too large, and that the proposal as to the establishment of an assurance fund was premature. Mr. Ford, however, regarded this proposal as a matter of necessity.

The CHAIRMAN, in reply at the close of the discussion, said they proposed to contribute only £2,000 a year to the assurance fund, and he trusted they would sanction this. It would assure those who belonged to it from £100 to £1,000 a year, the latter being the maximum. Tests were being made with regard to improvememts to the cables and as to constructing new cables; but he thought it would not be politic to proclaim to the world what they were doing in this matter. No stone would be left unturned to discover what was the best and most durable cable. The last two they made were improvements, and they might reasonably suppose that they would last much longer than the others. As to the duplex system, if they used the patent, it would cost them £1,500 a year. They had been experimenting, and they had already got 90 per cent. additional work out of the cables from the duplex. The bulk of the increase in the expenses, as compared with last year, had proceeded from the necessity of taking up and relaying the Duxbury cable in deeper water. The agencies had now been discontinued. They would be guided by legal advice as to the forgery of stock. If they did not see a reasonable hope of the judgment being set aside, they must write it off as a bad debt. The judge himself said that they had taken every precaution they legally could to prevent themselves from being swindled.

The report was then unanimously adopted, and the dividends recommended were declared. The retiring directors and auditors were afterwards re-elected.

The CHAIRMAN then moved a resolution as to the establishment of the proposed assurance fund, when an amendment was carried on a show of hands. It was, however, afterwards withdrawn, the directors undertaking to bring the matter before the next general meeting, and to send out notices stating that it would then be considered.

The proceedings then closed with the usual compliments to the Chairman.

THE SUBMARINE TELEGRAPH COMPANY.

The half-yearly general meeting of the above Company was held on Tuesday, the 11th of February, at the Cannon-street Terminus Hotel, under the presidency of Sir James Carmichael, Bart. The statement of joint earnings showed that the amount received in the half year was £59,926, and after providing for expenses—including £4,650 for repair of cables—this Company's proportion of receipts was £33,054, while the proportion to the French company was £6,683. There was an increase over the revenue of the corresponding half year of 1877, and they were enabled after adding the usual proportion of the receipts to the reserve fund, to recommend a dividend at the rate of 17½ per cent. per annum. The lease

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of their premises in Threadneedle-street, which was held under Government, would expire in 1880, and they had received notice that the lease could not be extended. They had, however, fortunately obtained an eligible site in Throgmorton-avenue, on a lease for eighty years, and they had entered into a contract for the erection of new offices for £16,229.

The CHAIRMAN, in moving the adoption of the report, said the only important point he had to refer to was the new building which they proposed to erect in Throgmorton-avenue. The change had become necessary on account of the Post Office requiring additional accommodation at the offices in Threadneedle-street, where the Company at present carried on their business. As a matter of fact, too, they had themselves outgrown the accommodation at their disposal at the present offices, and it became necessary either for the Post Office or the Company to give way. They could not find premises suitable for the Company without building, although they had been at some trouble to do so. The accommodation they required, however, was of a somewhat special character—for instance, they wanted a good basement for their batteries, and upstairs they must have first-rate light for their instrument clerks. They had obtained the ground at 6s. per foot, and the building would cost between £16,000 and £17,000. They estimated that, altogether, they would pay about as much for the new building—including ground rent and an adequate sinking fund—as they did now for rent to the Post Office, and they would have double their present accommodation. It would eventually turn out a good asset for their reserve fund. The revenue for the half year had slightly increased, which was always very satisfactory, but particularly so in face of the commercial depression. The Company's cables were in good working order. Two of the Government cables were just now under repair, and they were doing the work.

Alderman Sir T. DAKIN having seconded the adoption of the report, it was unanimously carried.

The dividend recommended was declared, and resolutions authorising the directors to apply to the Board of Trade for a supplemental charter to erect the new building, and to take a proportion of the reserve fund for that purpose, were afterwards passed.

A vote of thanks to the Chairman and directors closed the proceedings.

THE REPORT OF THE CUBA SUBMARINE TELEGRAPH COMPANY, LIMITED.

Report of the directors for the half-year ending 31st December, 1878, to be presented at the fifteenth ordinary general meeting of shareholders to be held on the 19th day of February, 1879. The directors beg to submit the balance sheet and accounts for the half year ending 31st December last, duly audited. From these it will be seen that the gross receipts for the half year, including the balance brought from last account, amount to £16,106 11s. 11d., and the expenses to £4,253 3s. 9d., leaving a sum of £11,853 8s. 2d. The balance, after providing for the preference dividend, would admit under ordinary circumstances of a dividend on the ordinary shares at the same rate as that declared for the corresponding period of last year. The directors regret, however, to report that the Company's original gutta percha cable broke down in the month of September last, and that there are signs of a fault in the new india rubber cable. Mr. Keith, the Company's manager in Cuba, is now engaged in the repair of the original cable, and when that is completed (of which intelligence may arrive at any time), he will proceed to the repair of the new cable. Under these circumstances, and having regard to the necessary outlay on these repairs, which cannot be accurately estimated at present, the directors do not think it prudent to recommend a larger dividend than 6 per cent. on the ordinary shares. After payment of the dividend of 10 per cent. on the preference, and that of 6 per cent. on the ordinary shares, there will remain the sum of £4,053 8s. 2d., which they recommend should be carried forward. Since the last report the decree of the Court of Madrid in the matter of the tax imposed by the Spanish Government upon the local business of the Company has been received, and confirms the statement then made to the shareholders. The directors have every reason to be satisfied with the conduct of the Company's case before the Courts at Madrid. The directors have to report that, in consequence of the final suppression of the rebellion in Cuba, the land lines of the Spanish Government are now competing with the Company's line. A falling off in local business may therefore be looked for in future.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES FEB. 12.		BUSINESS DONE WEEK ENDING FEB. 12. Highest.		Lowest.	
Anglo-American	60½,	¼	60½		59¾	
Do. "B"	86,	¼	86¼		85½	
Do. "A"	34½,	35	34¼		33¾	
Brazilian	6¾,	¼	6¾		6¼	
Cuba	8½,	9	—		—	
Do. Ten per Cent. Preference	15½,	16	—		—	
Direct Spanish	1¼,	2	—		—	
Do. Ten per Cent. Preference	10,	¼	—		—	
Direct United States	11¼,	¼	11¼		11¼	
Eastern	7¼,	¼	7 5-16		7 3-16	
Do. Six per Cent. Debenture	104,	107	105½		—	
Do. Five per Cent. do.	100,	103	101¾		100	
Do. Six per Cent. Preference	11½,	¼	11½		11½	
Eastern Extension	7½,	¼	7½		7½	
Do. Six per Cent. Debenture	101,	107	106½		105½	
German Union	7½,	8	—		—	
Globe Telegraph and Trust	5,	¼	5 3-16		5	
Do. Six per Cent. Preference	10 9-16,	11-16	10¾		10½	
Great Northern	7¼,	8½	8¼		8 1-16	
Indo-European	20,	21	20¼		—	
Mediterranean Extension	2¾,	3½	—		—	
Do. Eight per Cent. Preference	9,	¼	—		—	
Reuter's	10,	11	—		—	
Submarine	220,	225	223½		—	
West India and Panama	1¼,	2½	2		—	
Do. Six per Cent. Preference	8½,	¾	8¼		—	
Western and Brazilian	2¾,	3½	3		—	
West. Union Seven per Cent. 1st Mort.	114,	118	—		—	
Do. Six per Cent. Sterling	101,	103	—		—	

TRAFFIC RECEIPTS FOR JANUARY, 1879.

COMPANIES.	Jan. 1879.	Jan. 1878.	Increse.	Decrse.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,900 estd.	3,001	—	101
Direct Spanish Telegraph Company	951	944	7	—
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	24,695	22,905	1,790	—
Eastern Telegraph Company	39,226	41,531	—	2,305
Great Northern Telegraph Company	13,856	13,511	345	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

SUN ELECTRIC LIGHT COMPANY (LIMITED).

The Company are now prepared to entertain APPLICATIONS for ILLUMINATING all descriptions of PUBLIC BUILDINGS, PROMENADES, STREETS, MILLS, SHOPS, MINES, &c., by their Patent Process. All inquiries to be made at the Offices, 68, Cheapside, London, E.C.

J. P. BEDFORD, *Secretary, pro tem.*

THE SCHOOL OF
SUBMARINE AND MILITARY TELEGRAPHY.

ESTABLISHED IN 1868.

4, George Street, Hanover Square, London, W.

MANAGING DIRECTOR: MR. T. J. JONES, M.S.T.E.

The course of Practical and Theoretical Instruction in the higher branches of Overland and Submarine Telegraphy embraces, in addition to the manipulation of the various systems of working in general use, the following subjects:—

MATHEMATICS, MECHANICS, and CHEMISTRY, } In relation to Telegraphy.
ELECTRO-STATICS.
ELECTRO-DYNAMICS.
MAGNETISM.
SIGNALLING and TESTING INSTRUMENTS.
ENGINEERING FORMULÆ and their APPLICATION in PRACTICE.
METHODS of TESTING the ELECTRICAL CONDITION of a LINE DURING and AFTER its CONSTRUCTION.
TESTING FOR and LOCALISING FAULTS, &c., &c., &c.

The instruction, both in signalling and testing, is of a thoroughly practical character, as the classes work with the actual instruments used on long lines, through cables of various lengths, from 600 to 3,000 knots, so that the signals of the Eastern, Atlantic and Brazilian Co.'s, &c., are exactly reproduced, and the pupils fitted for any line.

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NOTES.

CABLE REPAIRS.—The cable between Pernambuco and Para is now restored.

COWPER'S WRITING TELEGRAPH.—Mr. Cowper's new "Writing Telegraph" will be brought before the Society of Telegraph Engineers at their next meeting on the 26th inst.

SOUTH AUSTRALIA.—This colony has nearly 5,000 miles of telegraph line in actual operation. This includes the line, 2,000 miles in length, through the continent, in connection with the submarine cable system to India, England, and other parts of the world.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).—Subject to the audit of the accounts, the directors propose paying a dividend of 15 per cent. (£1 16s.) per share, in addition to the *ad interim* dividend of 5 per cent. already paid, making 20 per cent. for the year 1878.

USE OF "EARTH" FOR COMPLETING A TELEGRAPHIC CIRCUIT.—According to Mr. John Finlaison, Prof. Aldini, about the year 1802, sent the current from a battery of eighty cells across Calais Harbour through a wire supported on the masts of boats, using the sea for the return current. It was not until 1837 that Steinheil perfected his telegraph, and showed that the return wire between two stations might be dispensed with; whilst the experiments of Mr. Alexander Bain, at the "Serpentine River," in Hyde Park, in which water and moist earth were made a portion of the circuit, did not take place until 1842.

THE ALBO-CARBON LIGHT.—This light, by which the eastern section of the Westminster Aquarium is at present illuminated, is produced by the combustion of gas which has been enriched by the vapour of a nearly white hydrocarbon, which, in the solid form in which it is supplied, has the appearance of sticks of cream-coloured sealing-wax (? napthaline). The vaporisation is effected in a metallic chamber of spheroidal form, fixed at a slight distance from the burner, so as to receive some of the radiated heat. The new light is considerably stronger, brighter, and steadier than ordinary gaslight, and appears likely to bring a considerable accession of strength to the cause of gas-lighting.

WINDING ELECTRO-MAGNETS.—We recently drew attention to a Paper submitted to the French Academy, describing a new and—so it was alleged—very advantageous method of winding electro-magnets, the point of departure being the same for each layer of wire. Mr. W. H. Preece, in a communication published in the current number of the *Journal of the Society of Telegraph Engineers*, says that the process is more difficult than that hitherto followed, the wire takes up more room, and there is nothing gained in power. On the contrary, says Mr. Preece, after trying both methods, "the old method proved itself to be superior in all circumstances." The matter is of some importance, and we shall be curious to learn more particulars concerning M. Bisson's mode of procedure, which probably has been imperfectly described.

ELECTRICITY APPLIED TO RAILWAY TICKETS.—An electro-magnetic railway-ticket counter, to indicate the number of passengers going by a particular train, and so the number of carriages of each class required, has recently been adopted, says the *Engineer*, at the station of the Kaiser Ferdinand's Nordbahn, in Vienna. The date press of each of the three ticket boxes is furnished with an electric contact, actuated each time a ticket is pushed in to be stamped. Three lines connect the presses with a clock-shaped counter in the office, where the train is arranged, having discs with numbers and pointers, so that the number of passengers booked can be seen at once. The arrangement conduces to promptness in ordinary circumstances, and, where great crowds are travelling, successive trains can be quickly despatched without overloading with passengers. Messrs. Meyer and Wolf, of Vienna, supplied the apparatus.

ELECTRICAL PHENOMENA DUE TO ETHER.—Within the last few years Professor J. Clerk Maxwell has shown the possibility that all electrical phenomena are due to pressure in the same ether, and this has long been assumed as the means of the propagation of light. Acting upon this assumption he has deduced what the laws of transmission of light in ordinary crystalline and magnetised media would be, and from such deductions he arrived at the laws of these phenomena. In a Paper recently read before the Royal Society, Mr. G. F. Fitzgerald, F.T.C.D., investigates the laws of the reflection and refraction of light upon the same assumption, and he has obtained the same results as Professor M'Cullagh long ago deduced from his theory, and which are known to represent almost exactly the laws of reflection and refraction at the surfaces of ordinary and crystalline media. Still further, he investigated the laws of reflection at the surfaces of magnets, with theoretical results which essentially agree with and completely confirm Mr. Kerr's recently-published experiments on the reflection of light from the pole of a magnet.

A NEW RELATION BETWEEN ELECTRICITY AND LIGHT.—Mr. J. E. H. Gordon presented a short Paper to the Royal Society at the meeting held on February 13th, describing an extension of the phenomena discovered by Dr. Kerr. The following is an abstract of the Paper:—In November, 1875, Dr. Kerr announced in the *Philosophical Magazine*, that he had discovered a new relation between electricity and light. He showed that, when glass is subjected to an intense electrostatic stress, a strain is produced which causes the glass to act like a crystal upon polarised light. On Wednesday, February 5, 1879, I was working at this experiment in the Royal Institution, and endeavouring, by means of the electric light, to project the effect on a screen, in preparation for a lecture on the next day. In the experiment as described by Dr. Kerr, and which was shown plainly on the screen, on February 6th, the light is extinguished by the Nicols, and reappears when the coil is set going. In the projection experiment a patch of moderately bright white light, about three inches diameter, appeared on the screen when the coil was worked. The images of the points inside the glass were about $1\frac{1}{2}$ inches apart. On Wednesday, however, the electrostatic stress was accidentally allowed to become strong enough to perforate the glass. Immediately before perforation there occurred the effects which are the subject of the present communication. First appeared a patch of orange-brown light about six or seven inches diameter. This at once resolved itself into a series of four or five irregular concentric rings dark and orange brown, the outer one being, perhaps, fourteen inches diameter. In about two seconds more these vanished, and were succeeded

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by a huge black cross about three feet across, seen on a faintly luminous ground. The arms of the cross were along the planes of polarisation, and therefore (the experiment being arranged according to Dr. Kerr's direction) were at 45° to the line of stress. The glass then gave way, and all the phenomena disappeared except the extreme ends of the cross, and the discharge through the hole, where the glass had been perforated, was alone seen. The phenomena were seen by Mr. Cottrell, by Mr. Valter (the second assistant), and by myself. A fresh glass plate was at once drilled in hopes of repeating the phenomena in the lecture next day, but owing to sparks springing round we did not succeed in perforating the glass, and therefore saw only the faint return of light described by Dr. Kerr. Some more glasses have been prepared and their terminals insulated, and I now propose to make another attempt to repeat the new effects before the Royal Society.

The Gas Light and Coke Company.—At the recent meeting of this Company the Chairman made the following remarks on the Electric Light:—"No doubt the meeting would expect a few words from him on that all-absorbing topic—the electric light. A report of the experiment made in that room had been circulated. He did not intend to enter into the mechanical or chemical process; his object would be to adduce certain arguments against the probability of electricity becoming an adversary to gas in any way. In the first place, its cost had been pretty well recognised, and it was rather pleasing that the result arrived at by their own committee as to the cost of the two articles very nearly coincided with that made in other and far distant places. In Paris the electric light had been in use for eighteen months. The other day the Electric Company applied to the Municipality of Paris for the extension of their term for lighting certain parts of Paris. Strong objections were made by many members, and especially by M. Malet, on account of the very great expense. The Electric Company, rather than lose the advertisement which they had so long enjoyed at the expense of the municipality, had agreed to light certain parts on the same terms as those of the Gas Company. Those terms would involve a loss amounting to about 75 per cent., although the price of gas, curiously enough, in Paris was provided for the public lighting at a much lower cost than it was to the general consumer. The Municipality had agreed to give them one year more at the reduced price; but at the same time they had allowed the gas companies, who were intimately bound up with the finances of the Municipality of Paris, to introduce lighting from gas of a superior description, and he had not the slightest doubt that it would be proved there, as it had been proved in London, that they could give light for light at considerably less prices than the Electric Company could pretend to do. The experiment in Paris showed that the cost of lighting by electricity was four times that of lighting by gas, and the extinction of the lights had risen from 1 to 20 per cent. there. The light had been tried on the Holborn Viaduct, the Thames Embankment, and in Billingsgate Market. He had received a return from the chief inspector of the Company that the lights were not free from extinction, and that occasionally the engines broke down. The lights on the Embankment had been unequal and flickering. In Billingsgate the men complained of the want of the warmth from the light, and asserted that the light had the extraordinary effect of changing mackerel into whiting [laughter.] On the 30th ult. the lighting of Billingsgate by electricity ceased. The same arguments might be adduced against its applicability for domestic purposes." We raise an emphatic protest against the idea that, because the cost of the electric light, as exemplified by the system in operation, far exceeds that of gas, it should be taken for granted that its price cannot be reduced. As a matter of fact, the light can be produced at half the cost, if not less, than is now the case on the Embankment or in Holborn. Our advice is, that gas shareholders should realise that time is given them to put their house in order—and that they should do it.

Thomson and Houston's Electric Lamp.—In Vol. I., page 282, we described a lamp devised by these gentlemen, so that the following extract from the *Engineering and Mining Journal* will readily be understood. The authors say:—"Some time ago, we published an account of one of the methods of using our lamp with vibrating electrodes, in our system of electric illumination. In this description, the current which gave the light also operated the vibrating device attached to the negative electrode. When a number of lamps are so used in one circuit, satisfactory results are not obtained unless each lamp is tuned to the same rate of vibration. We find that it is better to employ, to vibrate the electrodes, currents separate from those which produce the light. By the transmission of a single pulsating current through the electro-magnet coils of all the lamps in any circuit, synchronous vibration is readily imparted to the armatures or cores of the electro-magnet coils above mentioned, and through these to the electrodes. Our system is applicable to the use of direct or reverse currents. Where direct currents are employed, the arrangement above described is preferred. The existence of a cable of considerable length between any two lamps in one circuit is rather an advantage, provided the resistance of the cable is low, as the following reason will show. The extra current developed in the cable on the separation of the electrodes assists in preventing cessation of current due to excessive separation. The carbon electrodes used in our system vibrate through a comparatively small space, excessive vibrations being purposely damped. The steadiness of the light is thus secured. When reversed currents are employed, separate currents for vibrating the electrodes are not needed. The reversed currents, passing through a coil of wire surrounding a core of soft iron in each lamp, impart, when the coil is fixed and the core movable, a vibration to the core which bears the negative electrode. When, however, the core is fixed and the coil movable, the latter supports the negative electrode, and vibrates in the same manner. The reversed currents employed may be obtained directly from an alternating-current dynamo-electric machine, or the direct current from a dynamo-electric machine may be reversed by a commutator operated by the current, or other suitable means. When a number of small lights are to be operated by a single reversed current, this reversed current is caused to pass through the primary wire of a series of induction coils, the secondary currents of which feed the lamps. The use of induction coils in this manner allows the main circuit to remain unbroken, while the circuit of any of the lamps may be broken. The advantage of this in an extended subdivision of the light is evident. We have devised an electrical governor which, applied to a steam-engine driving a dynamo-electric machine, will maintain the current strength in its circuit. By this means, in the operation of a number of lights by a single current, the extinction of one or more of the lamps will not affect the others. We have also arranged the commutator of a dynamo-electric machine so as to obtain from it one or more reversed currents from the armature coils at the same time that the machine magnetises itself and furnishes direct currents from the same armature coils."

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FOUR LECTURES ON ELECTROSTATIC INDUCTION.

JAN. 16, 23, 30, AND FEB. 6.

BY J. E. H. GORDON, B.A.

(Assistant Secretary of the British Association).*

LECTURE I., JAN. 16.

"Amongst the actions of different kinds into which electricity has conventionally been subdivided, there is, I think, none which excels, or even equals, in importance that called *Induction*. It is of the most general influence in electrical phenomena, appearing to be concerned in every one of them, and has in reality the character of a first, essential, and fundamental principle. Its comprehension is so important that I think we cannot proceed much further in the investigation of the laws of electricity without a more thorough understanding of its nature. How otherwise can we hope to comprehend the harmony and even unity of action which doubtless governs electrical excitement by friction, by chemical means, by heat, by magnetic influence, by evaporation, and even by the living being?"

So, forty-two years ago, wrote the Master whose memory is honoured wherever the study of natural laws is loved, and whom in this place we should more especially remember, as the Royal Institution was his home and workshop during all the best years of his life. Need I add that the passage I have just read is from the "Experimental Researches of Faraday?"

The subject of our study to-day and in the other lectures of this course will be such of the laws of induction as are now clearly known. I shall first endeavour to show you what the term induction means, and what is the problem about it which for fifty years students of nature have been trying to solve. The problem is partly solved now, but much remains to be done. It will, I think, be pleasant to follow the stages of discovery up to to-day, and perhaps to look a little forward and try to see what the discoveries which may some day be made may lead to.

First, we have the simple phenomena of induction and electrification, some of which I shall shortly show to you.

The unsolved question, "What is electricity?" we shall not attempt to touch upon. It is sufficient for our purpose to know that when a body exhibits certain properties it is said to be electrified, or to be in a state of electrification. We also know how to produce this state at will, but we know next to nothing of its nature. We do not know whether the properties of an electrified body are caused by one or two electric fluids entering it or leaving it, as water into a sponge; or by a motion of its molecules, as when a body is heated; or by a strain or twist of its structure, as when steel is magnetised.

We have no conception of electricity apart from the electrified body; we have no experience of its independent existence. Let us now begin the study of certain phenomena of electrification which it is necessary for us to understand before commencing the study of induction.

If we rub a piece of sealing-wax or glass with a silk handkerchief we find that it has the power of attracting light bodies, as you see. The glass or sealing-wax, after being rubbed, is found to be in the state called "electrification."

When I hold the electrified body near these light paper shavings, the action takes place from the sealing-wax *across the intermediate air*. What is the nature of the action? We do not fully know yet, but it is called *Induction*.

This is only one form of induction, but I shall hope to show you others. Meanwhile, note the following definition to begin with.

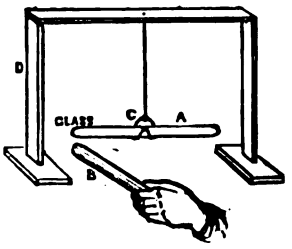
Every electrified body from which no electrification is allowed to escape has a particular action on all neighbouring bodies, and this action is called induction.

Before we go any further in the study of induction we must inquire, Is there any difference between the electrification produced by rubbing sealing-wax and that produced by rubbing glass? We may answer at once that there is, and the difference is a very curious one, namely, that the properties of the two kinds of electrification are exactly opposite to one another. By opposite I mean this: if by any means equal quantities of the two electrifications be added together, they will exactly neutralise each other, or, in other words, adding a quantity of one kind of electricity is the same as taking away an equal quantity of the other. There are a great many ways of producing electrification, but all electrification is of one or the other kind, either that of glass or that of sealing-wax. For convenience, glass electricity is called + sealing-wax electricity −. Here I have an electric machine, which is simply a convenient method of rubbing glass and silk together.

* Delivered at the Royal Institution 1879.

I have shown you one form of induction, namely, the attraction of light bodies by an electrified body. Let us now examine the effect of electrified bodies on each other. Here I have some pieces of sealing-wax and glass, and a means of suspending any one of them. We find that sealing-wax repels sealing-wax, glass repels glass, glass and sealing-wax attract each other, or, generally, like electricities repel, unlike attract. Hence you see that there is always a force acting between electrified bodies, and that, when the electrifications are alike, it is a repulsive force, when different, it is attractive.

FIG 1

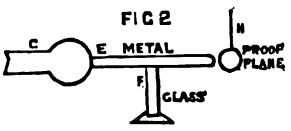


This force acts through the air or *other substance* between the electrified bodies, as you see when I put this plate of paraffin-wax between the suspended rod and the one in the hand. It is, therefore, a form of induction. What is the machinery that conveys this force across the air or paraffin? This is a question to which we shall attempt to give a partial answer later on.

Conductors and Insulators.—In certain substances, such as metals, electrification is able to move freely; that is, if one end of a metal rod receives electrification, the electrification is at once *conducted* to every part of it, as you may here see.

The proof plane being applied to the end furthest from the machine, it is found to be electrified. These substances are called conductors. In other substances electricity is not able to move freely, and if one end is electrified, the other remains in an unelectrified state, as may be seen by substituting a glass rod for the metal one in the preceding experiment. The electricity being *insulated* at the first end, these substances are called Insulators. It is possible to insulate a conductor by placing it on a glass stand, and we can then study the movements of the electricity in it without the latter being able to escape.

FIG 2



We are now in a position to study the effect of the induction of an electrified body upon a conductor near it. Here is our conductor L, and we will place it near the charged knob K of the electric machine. The jumping up of these paper slips shows that the metal is electrified, but no electricity has passed to it, and it is electrified by induction. Thus we learn that by induction an electrified body electrifies bodies in its neighbourhood. This metal rod is electrified, although no electricity has been transferred to it. Let us now examine what difference there is between the electrification produced in this rod by *conduction*, or direct transfer of electricity, and by *induction*. First let us electrify the rod by conduction, and let us, after stopping the machine, test both ends with the proof plane. We see that both ends are *positively* electrified. We have stopped and discharged the machine, but still the electricity remains in the cylinder, and will remain there until some *conducting* path is opened for it, as by touching it with the finger. The actions are just as if a portion of an electric fluid had been forced from the machine to the cylinder, had distributed itself all over the latter, as water finds its own level, and had now been drawn off through my body as water through a pipe. Let us now return and examine the parallel induction phenomena. We see by the attraction of the papers that the cylinder is electrified at both ends. Let us now examine what kind of electricity there is at each end. We find, first, that the end nearest to the machine is −, the far end +. We now see why electrified bodies attract light objects; they first induce on the side nearest to them an electrification opposite to their own and then attract it. Let us now stop the machine. All signs of electrification disappear. Thus we see, when electrification is produced by induction, there is nothing analogous to the transfer of fluid from the machine to the cylinder. It is more as if, to use a bold simile, by some straining force, the cylinder was distorted into an electrified state, and, just as when we distort a plastic substance, any increase of length is accompanied by a corresponding decrease of thickness, so that the volume remains the same. So, when we electrically distort this cylinder by induction, every increase of electrification at one part of it, that is, any appearance of + electricity, is accompanied by a decrease of electrification at another part, that is, an appearance

FIG.3.

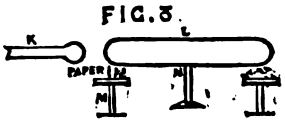


FIG 4

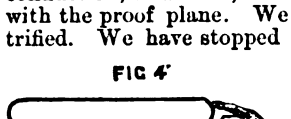
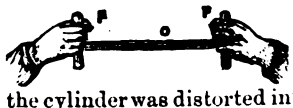


FIG 5



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of — electricity. The most rigorous and accurate experiments have shown that these two quantities, viz., the increase and decrease of electrification in a body, when acted on inductively, are exactly equal. I can show you a rough experiment to illustrate this point. I have here two gold leaf electroscopes, which are exceedingly delicate machines, for detecting small quantities of electricity. We now again electrify the cylinder by induction, and by means of the proof plane transfer a little electricity. from each end to the electroscopes respectively. We now stop the machine and remove the cylinder. Each electroscope remains charged, one + and one —, and each with a charge whose strength is proportional to the induced charges on the two ends of the cylinders respectively. If these charges are equal, they should neutralise each other when I connect the electroscopes, and you see they do so. The reason why it is so important that we should see clearly that equal quantities of both kinds of electrification are always produced by induction is that this experimental fact shows us that the action of induction is to produce something analogous to a distortion of the electrified body, and that, if this were not the case, but a greater quantity of one kind of electricity than another was induced, it would show that something had been added to or taken from the induced body, and the action would be more analogous to a change of bulk than to a distortion of molecular shape. The problem, then, that we have before us is: "Given the known experimental facts which we have just been considering; given that there is an action, which we call induction, across air and other insulators from an electrified body to other bodies in the neighbourhood; that the induction causes these attractions, and repulsions, and "inducings" of electrifications which we have spoken of, what is the machinery by means of which this induction acts? What is the nature of the lever, the rope, or the pushing pole, which strains, and pulls, and pushes across the air, or glass, or other non-conductor which we place between the induced and inducing bodies?" We must attempt to answer these questions bit by bit, and our first attempt shall be based on the difference between Induction and Conduction.

FIG. 6

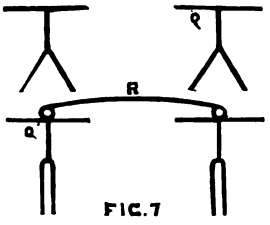
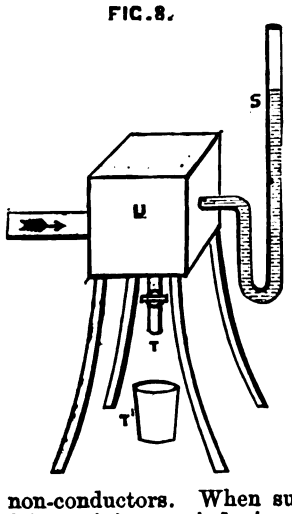


FIG. 7

We have seen that when a piece of glass or other insulator is placed in contact with the conductor of an electric machine it is thrown into a state of strain and distortion, but that the electricity does not escape through it. When, however, a metal or other conductor takes the place of the glass, there is no appearance of such a state of strain at all. What is the explanation of this? It is this. Equally in conductors and insulators a state of strain occurs, but in conductors this state of strain is continually giving way, while in insulators it does not do so. To keep up the state of strain in a conductor would be as difficult as to keep up a pressure of steam in a boiler with a large hole in it.

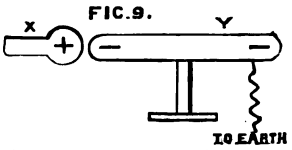
Let me show you a mechanical experiment in illustration—only in illustration, remember, not in explanation, of what I mean. Here is a vessel, U, connected to the water pipes at one end and to a pressure gauge, S, at the other. There is no escape for the water, it cannot flow or move, and the gauge shows a considerable pressure. I now turn the tap, and allow a stream of water to escape. The pressure and strain is relieved and the gauge falls; that is, as soon as the state of constraint gives way and the current flows, it is seen that the strain no longer exists. In the analogous electrical case, bodies in which the state of constraint easily gives way do not show the phenomena of strain or induction, but allow the electricity to flow freely, and these are called conductors; while, on the other hand, bodies which have a great power of resistance to the straining force can be greatly strained without allowing a current of electricity to flow. These are called insulators or non-conductors. When such a body is subjected to a powerful straining or inducing electric force it exhibits the phenomena of strain or induction very strongly. Let me now show you an experiment illustrating what I have just stated.

FIG. 8.



You remember that when we placed the insulated cylinder near the machine the induction which took place charged the near end — and the far end +. In this experiment we are only concerned with the near end, and we will lengthen our cylinder so as to get the far end out of our way. How are we to do this? This is a large room, and no doubt we might, at some considerable trouble and expense, so lengthen the cylinder that we could remove its other end to a distance of some 20 or 30 feet. But we can do better than that. We will make the whole world part of our conductor. The earth, owing to the water in it, is a good conductor. We will connect this wire from the cylinder to the water pipes, and now we have one end of our conductor on the table and the other safely out of our way somewhere in Australia. Now you see there is air in the space between the machine and the cylinder, and the state of strain will commence as soon as I begin to work the machine, as you see by the divergence of the gold leaves of the electroscope when I take the proof plane from the cylinder to it; in other words, electricity is induced on our end of the conductor.

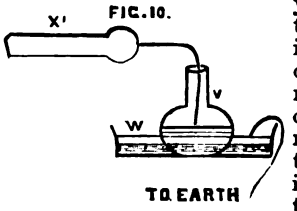
FIG. 9.



This induced electricity will remain here during the action of the machine as long as the air or other insulator is between the plates; that is, as long as the substance between the plates resists the straining force, so long will the state of strain be kept up. If, however, I connect the plates by some substance which offers an exceedingly small resistance to the straining force, as this metal bar, the state of strain at once gives way, and all induction ceases, and no divergence of the electroscope can be obtained. The electricity at the same time flows away, and distributes itself in the earth. This experiment is somewhat analogous to the mechanical one I showed you, where the strain was relieved by opening a tap and allowing the water to flow away.

The particles of glass move more freely over each other when hot than when cold, and hence we should expect that hot glass would yield more easily to a straining force than cold glass would. The following experiment shows that this is the case. Here is a glass flask containing mercury, and set in a dish of mercury. The mercury inside is connected to the electric machine, and that outside to the earth. On working the machine it is found, first, that no electricity can escape through the flask; secondly, that there is a strong induced charge on the mercury outside. Now let the mercury be made hot. It heats the glass, the particles move more freely over each other, the glass yields to the straining force, electricity escapes through it, and at the same time all induction ceases.

FIG. 10.



We have, in this lecture, by various means produced electricity, and we have produced sometimes one kind, and sometimes the other. It is important to examine whether we can actually produce one kind alone. If this were possible, we might actually increase the quantity of electricity in the world. Experiment shows us that we cannot do this. For every bit of + electricity that we produce we produce an exactly equal quantity of —. We cannot make or destroy electricity; we can only strain bodies so that their two ends shall show opposite electrical properties. When we rubbed glass we produced + electricity on its surface. Was not that a creation of electricity? No, for an exactly equal quantity of — electricity was produced on the rubber, as I can show you. (The rubber, on being laid on the electroscope, caused a strong divergence of the leaves.) To show that this — is equal to the +, a very simple experiment will suffice. I rub this sealing-wax till, by the cracking, you can hear that it is highly electrified, but do not remove the rubber from it. You see there is no effect on the electroscope. The reason is that the action of the — on the rubber exactly balances that of the + on the sealing-wax.

In the electric machine itself equal quantities are produced, only the rubbers are connected to the earth, so the — escapes, and only the + is kept. Here is the machine placed on an insulating stand, and a wire from the rubber brings the — as well as the + to the conductor. I work the machine, and you see even the gold leaf electroscope shows no sign of electrification. This shows that equal quantities are always produced. But when we rub sealing-wax and silk, and put down the silk on the table, the — electricity escapes to the earth, and is neutralised and lost, and we have to all appearance + alone in the wax. No; for the instant the balancing — is removed, the +, by induction, produces a fresh — on all surrounding bodies. It does so then, and not till then, as we may see by making one of those neighbouring bodies the electroscope, while the rubber, if it is not discharged, but removed, induces + on bodies near it. No electrification of one kind only can be produced any-

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where. If we charge a balloon +, and send it up as high as possible, it will still induce an equal opposite charge on whatever is nearest to it, be it earth, clouds, or clear air. We have no means of knowing how much or in what way the earth itself, with its atmosphere, is charged; but this we know, that, whatever its charge may be, it will induce an exactly equal opposite one on the moon, the sun, and even the most distant stars.

THE SOCIETY OF TELEGRAPH ENGINEERS.

ON "THE WORKING OF LONG SUBMARINE CABLES."

BY WILLOUGHBY SMITH.

(ABSTRACT CONTINUED FROM PAGE 149.)

The object in the system introduced by Mr. Willoughby Smith was to keep up a constant test for insulation and continuity, and at the same time to communicate freely through the cable between the ship and the shore.

After pointing out how a condenser may be formed by placing a certain length of cable-core in an insulated tank, and how an imperfectly insulating condenser was actually constructed by placing a series of sheets of tinfoil and gelatine alternately one on the other, the author stated that he connected one set of alternate sheets of tinfoil to the shore end of the cable conductor, whilst the other alternate sheets were connected to the terminal of a very sensitive astatic mirror galvanometer, of which the other terminal was led to earth. Consequently, the current which passed through the sheets of gelatine flowed through the galvanometer to earth, and a constant deflection was registered so long as the cable was kept charged at a uniform tension. But if the tension were altered, or the direction of the current reversed, the change of the deflection was immediately noticed by the person in charge of the galvanometer on shore, with whom the person in charge of the batteries on shipboard could thus communicate, by a pre-arranged code of signals, without interfering with the insulation test, since the current passing through the gelatine plates was hardly sufficient to increase the deflection on the ship galvanometer.

To enable the person in charge of the shore galvanometer to communicate the continuity or speaking signal to the ship, two resistance coils of unequal resistance, and a key through which the cable could be connected to earth through either coil, were employed, so that a minute portion of the cable charge could be allowed to pass to earth, the contact through one coil giving a signal corresponding to the Morse dot, and that through the other coil a signal corresponding to a dash.

This system was reported upon very favourably by Mr. Latimer Clark and Sir W. Thomson, who testified that it solved the problem of giving an absolutely continuous test of insulation whilst allowing signals to be transmitted in either direction and tests to be applied for continuity. At the suggestion of Mr. Laws the resistance coils were afterwards replaced by condensers of unequal capacity, an improvement by which several advantages were obtained. This plan, however, was superseded by one which was suggested by Messrs. Thomson and Varley, in which a single condenser only was used, the signals being produced by reversals from a local battery, which increased or diminished the deflection on the ship galvanometer by induction through the condenser. Mr. Willoughby Smith's system of simultaneous testing and signalling, thus modified, was employed during the laying of the 1866 and the completion of the 1865 cables, allowing of the transmission of 164 messages between the ship and the shore. It was, said the author, soon apparent that a higher speed would be obtained by the use of a condenser than by the "curb key;" consequently, the system of signalling was continued after the laying of the cable, and a speed of thirteen words per minute was attained with perfect ease.

Subsequently, on his return home, Mr. Willoughby Smith further altered and simplified the arrangements as follows:—The cable at each end was connected with a switch playing between a "receive" and a "send" contact. To the former was connected a condenser of a capacity equal to 75 miles of the cable; the other side of this condenser being to earth through the receiving galvanometer. The "send" contact stud was connected with a reversal key, by which currents from a 10-cell battery could be transmitted through the cable. The operator at either station, when wishing to speak, would "switch over" to the stud marked "send," and commence sending reversals to represent the usual call signal; then "switch over" again, and wait until he received the reply to his call, when he reverted to the former contact, and transmitted what he had to communicate. With this simple arrangement the author had seen 25 words per minute received at Valentia from Heart's Content, through 1,900 nautical miles of cable, with the most perfect ease. If, said he, we consider what 25 words per minute really mean, we shall be better able to realise the credit due to those gentlemen who are what is termed "good mirror clerks." To obtain this speed, the sender has to manipulate the springs of the key so as to make 375 contacts per minute, and the receiver has to distinguish, in the same space of time, the true from the false in the 750 movements of the small beam of light which moves either to the right or left on a strip of cardboard placed before him. This system has now been in use for twelve years on the Atlantic cables, and has been adopted for working all the cables laid during that period; and for speed, simplicity, economy, and accuracy it has not been surpassed.

After giving a practical instance of the superiority of this system, the author stated that the only objection he had ever heard brought against it was that the mirror galvanometer is not a recording instrument. To meet this objection, the very ingenious but complicated and expensive "Syphon Recorder" of Sir W. Thomson, patented in 1867, was introduced. When this is used it replaces the mirror galvanometer as the receiving instrument, the other parts of the system remaining intact. Mr. Willoughby Smith gave a simple description of this recording instrument, and stated that, in his opinion, the mirror is the superior instrument.

In 1873, Sir W. Thomson and Prof. Jenkin conjointly patented "the Automatic Curb Sender"—a combination of the "curb key" and Sir C. Wheatstone's well-known "automatic sender." This instrument, in the opinion of the author, is a step in the right direction, but will be of little value until a suitable receiving instrument is discovered to work with it.

After pointing out that the use, in conjunction with a condenser, of resistance coils connecting the cable to earth could only be of detriment in the present system of working long cables, the author of the paper referred to the fundamental law of induction on which this system is based, and afterwards entered into some very interesting details as to the extreme minuteness of the current producing the signal on the mirror galvanometer when a condenser is used. Assuming the currents from ten Menotti cells to be sent into the cable on each contact at the sending station, then the amount of induced current passing through the receiving galvanometer would be equal to about 1-40,000th part of that current. The cable is only partially discharged between each signal, by each spring of the sending key being put to earth after it has been depressed to charge the cable. To give some idea of the very small amount of current which actually gives the signal, it was mentioned that a sempstress, whilst manipulating with her needle and thimble, generates a stronger current, and that a knife and fork inserted into a steak or chop at lunch produces a current of six times the amount.

In regard to the employment of electro-magnets with a view to increase speed of signalling, an experiment was described in which the induced magneto-electric charge totally neutralised the charge from the battery, so that no discharge could be obtained from the cable. Nevertheless, experiments with electro-magnets, placed in every conceivable way, gave results which were in all cases unfavourable to the employment of electro-magnets as shunts.

Referring to the application to long submarine lines of the duplex system of working, Mr. Willoughby Smith explained that the principle of signalling remains the same as that above described, but the receiving instrument at each station is so placed that the current sent to the distant station does not affect it. To insure good duplex working, a true balance must be established at the sending end, so that no current will pass through the receiving instrument when placed as a bridge between the real and the artificial cables.

In concluding the Paper, which was illustrated by a number of diagrams and some interesting fac-similes of signals received under various conditions by the syphon-recorder, Mr. Willoughby Smith said that, although wonderful progress had been made in electrical science during the last few years, he believed that we are only on the threshold of what we may be permitted to know, and that there are before us gleams of light which, if rightly pursued, will richly reward the patient and honest explorer.

APPARATUS FOR ELECTRICAL STUDENTS.—The attention of our foremost makers of philosophical instruments requires, we think, to be directed to the necessity of producing a set of instruments sufficiently reasonable in price to be within the means of ordinary students, and yet of such a character as to place them beyond the category of scientific toys, and to render them, with due care, useful in familiarising the learner at least with approximate galvanometric measurements. These instruments should include a simple reflecting galvanometer, with shunts, and some kind of rheostat. We feel certain that there are many scientific electricians who would give their co-operation, on very easy terms, to secure such a boon for electrical students, the number of whom is year by year increasing.

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THE ELECTRICIAN.

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MONOPOLY AND INVENTION.

Circumstances fresh in the recollection of our readers induced us to give space in these columns to a correspondence relating to Government treatment of inventors, and the effects of monopoly upon invention generally. The discussion had a particular reference which we do not propose to revive. Although our interests, and those of the majority of our readers, are intimately concerned with electrical, and perhaps chiefly with telegraphic matters, we may usefully review the broad question of monopoly in its relation to invention without taking sides in a particular quarrel. We shall certainly be impartial; and we hope to draw attention to some points which are often lost sight of in angry disputation.

The question, Does monopoly discourage invention?—for this is how some people always frame it—might be a fruitful topic for a debating society, but it can have little public interest until we have a clear answer to the further questions, What is monopoly good for? and, What is invention good for? We may even get enlightenment on these points, and yet leave the practical problem at the root of them unsolved, namely, Whether the community is on the whole benefited by monopoly. If yes, then it follows that invention, like competition, in so far as it stops the way, must abate its pretensions for the sake of the general good. But, as a matter of fact, there is no need to search for an answer to this latter proposition. When a nation has become convinced that unrestrained competition has had its day—in other words, has served all the purposes it is expected to serve—and freely reconciles herself to monopoly as the only practical escape, she dismisses all doubts as to its inherent demerits as abstract speculations. She has her grumble now and again when the vicious side of her new servant displays itself; but as she can never discharge or disown it, there is no use discussing afresh its characteristic shortcomings.

These considerations will, we are aware, have very little weight with people who continually hold up the reign of Charles I. as a warning, and are the irreconcilable foes of monopoly in every era. Persons of strong individuality and bold originality are always its sworn adversaries—if they have no hand in it themselves. Inside it, this class of mind is its staunchest upholder, and, it must be added, its chief adornment; for without the presence of such minds monopoly would soon become intolerable. A glance round the great monopolies of this country, governmental and commercial, will reveal the fact that they have, generally in their origin, always in their organisation, been the work of men of the type to which we have just referred. Nor can it be said that the task of maintenance is now in more feeble hands. We certainly have not arrived at the torpid stage, and it is hardly to be apprehended that we shall ever arrive at the corrupt stage. Times change, opinions change, as well in social as in political affairs. A generation back competition was an absolutely sacred thing among us. Carlyle smashed that idol, and we have, perhaps somewhat irreverently, walked over the fragments. We are not, however, at present in any danger of setting up another deity in its place. If we cannot check the tendency which is undoubtedly bringing about the agglomeration of small undertakings in these latter days, we can criticise it, call it to account, and in many ways efficiently control it.

Should the triumph, step by step, of this tendency bring with it the extinction of inventive effort, here indeed would be a loss which no nation can afford to sustain. But so far from being necessarily the cause, monopoly is in part the result of such extinction, and in part of invention being misdirected or inequitably distributed. A monopoly not wielded in the interests of individuals, but for the common good, ought to, and usually does, insure for all alike the best that invention has yet produced. And it is tolerably certain that when a government monopoly discovers, as it speedily does, that it is falling behind its neighbours, it will either supply or call in the requisite inventive energy. That this is not mere conjecture, and that invention has not been starved out, is pretty plain from the fact that we are not behind other countries, and are ahead of them in some respects—notably where monopoly has fullest sway.

But it does often happen that inventions receive but scant attention at the hands of monopolists, and this brings us to

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the question how much of this is due to monopoly considered as such? The truth seems to be that, while enterprise is in process of growth and expansion, there is a wide field for the inventor, and this very often from causes nearly akin to monopoly itself. Rival adventures are glad to adopt a new invention, for the precise reason that their competitors have obtained a practical monopoly of the old. When this immediate aim is served, an inventor might as well suggest a reduction in the directorial fees as the adoption of an improved instrument. This species of competition, such as it is, cannot last for ever; and, unless we are prepared to go the length of saying that all new devices are good simply because they are new, a line must be drawn somewhere. Private companies draw it, often all too soon, at their pocket holes. Amalgamation, ending in complete monopoly, draws the line at public convenience. The inventor's difficulty now is, that he has to outstrip the best selected appliances which the monopoly has been free to choose from; and whilst, at one time, he was sometimes able to start a fresh "company" on the basis of a new instrument, his only chance now is to better the surviving fittest. Thus the field of invention is undoubtedly narrowed, and it is not to be wondered at that the persons most affected bewail the change as having converted the mother of invention into a somewhat hard-hearted mother-in-law. But, after all, the community was not made for inventors, but, rather, inventors for the community; and the practical issue resolves itself into this,—Does the community, under these altered conditions of circumstance and temper, actually discourage innovation, good, bad, or indifferent? Seeming instances of the kind do occur now and then, but only for a time. In the long run, any veritable utility has always prevailed, and, in a country of free discussion like ours, we venture to hope, always will prevail.

While led to these conclusions, however, we are strongly of opinion that inventors should be respectfully, and even tenderly, treated by the monopolies. This much, indeed, ought to be one of the conditions, taken for granted, upon which private competition is superseded. There should be no prejudice against inventors as such, and there ought to be liberal facilities, with the most competent judges, to test the merits of all reasonably hopeful inventions. But we have expressed our views on these points so recently that we need not travel the ground again.

In this survey of the question, brief as it necessarily is, we must not omit one factor which the advocates of monopoly may reasonably adduce in its favour, and which, if it does not console the inventor, will commend itself to the scientist. The fact that mere variation in the way of doing a thing, which constitutes a large part of the business of the inventor, has no longer any chance of obtaining distinction, gives a marked impulse to discovery. This has long been the case in respect to warlike appliances, and of late has been conspicuously so in relation to telegraphy. Almost every recent improvement has been the result of new revelation in the domain of electrical laws. This is a cheering sign, and, when we are weighing the disadvantages of monopoly, counts for a good deal in the opposite scale. That some of the most remarkable discoveries come to us from a country where there is still much freedom of competition does not affect the general truth. They are evidence that ingenuity, as apart from science, has accomplished its utmost, and that the future is for the scientist. There is no reason to fear that research will receive less encouragement at the hands of Governments than from those of private speculators. Indeed, arguing both from theory and from actual experience, the probabilities are all the other way.

THE PROPOSED TELEGRAPH THROUGH CENTRAL AFRICA.

It has been very difficult for any one to gather from the expressed opinions of the exponents of this scheme any clear idea as to the means they propose to adopt in order to carry it into effect. One estimate gives as the cost £500,000, but the principal speaker in the deputation to the Colonial Secretary on the 13th February gave as the cost £750,000. We can hardly suppose that any really scientific estimate has been made, but what has thus been stated is the outcome of a casual glance at the subject. The engineering difficulties in the way of such a work are enormous, and when these have been surmounted, as they can be, *at a cost*, electrical difficulties must be encountered, and how these are to be overcome has not yet been satisfactorily explained. According to Captain Mayes, for hundreds of miles over part of the proposed tract the tropical vegetation holds sway, and if a road of twenty feet in width be cut and the roots of the trees grubbed up, in a few months, unless there is a constant stream of traffic, the whole is again covered with an impenetrable jungle. Then all the materials, posts, wires, insulators, tools, and even the food, or merchandise wherewith to obtain food, must be carried in some parts by the aid of coolies. Electrically, the insulation of the line would be about as bad as one can suppose a line to be. Portions of its course being in two tropics, there would be a double rainy season to be guarded against; and be it remembered that rain in England is one thing and rain in the tropics another. It would be extremely difficult to send messages during a tropical downpour over long lengths of land line—and, if we consider the effect of the luxuriant vegetation probably coming into contact with the wires, we should say almost impossible. We are glad to see that Mr. Donald Currie, the able advocate of the West Coast cable, has no word to say for the land scheme, but says if there is greater difficulty in laying a cable by the West Coast than by the East Coast, by all means let us have the latter. He believes, as must every one who has studied the subject, that telegraphic communication with the Cape by means of a cable is essential—essential commercially, essential politically. Mr. Young, in a communication to *The Times*, says:—"I see advocated a scheme of laying a telegraph to the Cape through Central Africa. I consider such a project to be altogether impracticable for some years to come, for the following reasons:—A great portion of the country through which it is proposed to construct this line of telegraph is altogether unexplored, and only with the greatest difficulty have travellers penetrated to those parts which are better known. How, then, could the requisite material be transported thither? Supposing even this objection to be overcome, the elephants, which abound nearly everywhere and delight in uprooting even immense trees, would speedily lay every post level with the ground. The poles, which the climate would render dry, in six months would be totally destroyed by the fires which every year entirely consume the grass and bush. It would be impossible to keep the line in repair; most of the native tribes, instead of so doing, would soon be using the wire for ornaments."

We trust that after these statements have been considered we shall hear no more about a scheme which, upon the face of it, bears no stamp of practicability. According to a casual statement of Mr. Donald Currie, made on the occasion of the departure of the Dublin Castle with troops for Natal, the Government has practically decided to give the required support for the laying of the East Coast Cable, from Aden southwards, *viâ* Zanzibar.

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CORRESPONDENCE.

ELECTRICAL "POTENTIAL."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am surprised to find that some electricians are still not satisfied that there is any *raison d'être* for the term Potential. They might just as well object to the use of any name for the physical quantity we speak of as temperature. Temperature is to heat as potential is to electricity.

Whether temperature be a good or a bad *name* for the thing itself is a question merely of nomenclature, but it has established usage on its side; and whether potential be a good or a bad *name* for the thing is also a question of nomenclature, and has established usage on its side. The mathematicians evidently think it a good name, and so it seems to me, for the electrical potential of a point is simply the potential energy of unit positive electricity if placed there.

But it is not as a question of nomenclature that the objection is made. It is asserted roundly that there is no need for any such term, because there is no physical reality that one wants to express. This is simply false, precisely as false as if it were asserted, as no doubt it has been before now, that there is no physical reality expressed by the word temperature. If it be agreed to use the word "tension" in this sense, instead of the word potential, well: so long as it be defined to mean this, and is used definitely and not vaguely, as so many terms are at present (*e.g.* "tension of current," "density of current," and many such meaningless abominations)—*well*, but not *good*, because the word tension is wanted for another and entirely different thing, viz., the force with which a charge of electricity tends to repel itself from a conductor ($2\pi\rho^2$), *i. e.*, for the strain in the dielectric per unit of area. The *potential* inside a hollow charged vessel is the same as that of the surface, but few electricians would be found to assert that there is any *tension* inside a closed cavity. If people, before setting themselves up as judges of the utility of mathematical terms, would try and understand first what they mean, we should get on better.—Yours, &c.,

OLIVER J. LODGE.

THE ELECTRIC LIGHT IN COAL MINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If M. Boullenot (p. 153) desires to maintain a valid patent he had better take an early opportunity to *disclaim* "the use of electricity as a means of lighting coal mines." There would be some sense in the objections to patents if every separate use to which a thing could be turned were permitted to form the subject of a patent. The electric light can be used anywhere by any one who pleases. Besides this, however, the use of the electric light in mines was publicly proposed many years ago, and I made several experiments myself to see if the light of vacuum tubes could be employed as a substitute for the safety lamp at least twelve years ago. I say nothing as to M. Boullenot's plan, as I know nothing about it. If he has a good mode of applying the light, well and good. May he have all success; but it is simply absurd to claim generally "the use of electricity as a means of lighting coal mines." Such a claim would invalidate his patent.—Yours, &c.,

J. T. SPRAGUE.

THE EDISON ELECTRIC LIGHT.

We are indebted to our contemporary, the *Engineer*, for the accompanying diagrams. As we stated in our last issue, the French specification of Mr. Edison is published. The specification consists of three parts—the first refers to a new device in magneto-electric machines, which is thus described:—"It has long been known that if two electro-magnets, or an electro-magnet and a permanent magnet, be drawn apart or caused to pass by each other, electric currents will be set up in the helix of the electro-magnet. It has also been known that vibrating bodies, such as a tuning fork or a reed, can be kept in vibration by the exercise of but little power. I avail of these two known forces and combine them in such a manner as to obtain a powerful electric current by the expenditure of a small mechanical force. In Fig. 1 of the drawing a tuning fork, a^2, is represented as firmly attached to a stand, b^2. This fork is preferably of two prongs, but only one might be employed upon the principle of a musical reed. The vibrating bar or fork may be two metres long, more or less, and heavy in proportion. It has its regular rate of vibration like a tuning fork, and the mechanism that keeps it in vibration is to move in harmony. A crank and revolving shaft, or other suitable mechanism, may be employed, but I prefer a small air, gas, or water engine, applied to each end of the fork. The cylinder a^1 contains a piston and a rod, b^1, that is connected to the end of the bar, and steam, gas, water, or other fluid under pressure acts within the cylinder, being admitted first to one side of the piston and then the other by a suitable valve; the valve and directing rod c^2 are shown for this purpose. The bar of fork a^2 may be a permanent magnet or an electro-magnet, or else it is provided with permanent or electro-magnets. I have shown an electro-magnet, $c\ c^1$, upon each prong of the fork—there may be two or more on each—and opposed to these are the cores of the electro-magnets d. Hence, as the fork is vibrated a current is set up in the helix of each electro-magnet d in one direction as the cores approach each other, and in the opposite direction as they recede. This alternate current is available for electric lights, but if it is desired to convert the current into one of continuity in the same direction a commutator is employed, operated by the vibrations of the fork to change the circuit connections each vibration, and thereby make the pulsations continuous on the line of one polarity. A portion of the current thus generated may pass through the helixes of the electro-magnets c^1 to intensify the same to the maximum power, and the remainder of the current is employed for any desired electrical operation wherever available. I, however, use the same, especially with my electric lights, but I remark that electricity for such lights may be developed by any suitable apparatus. I have represented commutator springs or levers, $c^3\ c^4$, operated by rods that slide through the levers $c^3\ c^4$, and by friction move them. When the prongs $a^2\ a^2$ are moving from each other the contact of levers $c^3\ c^4$ will be with the screws 40 41, and the current will be from line 1 through c^1 to c, thence to c^3 to 41 43, and to circuit of electro-magnets $d\ d$, and from $d\ d$ by 42 to 40 c^4, and line as indicated by the arrows. When the prongs $a^2\ a^2$ are vibrating towards each other the circuit will be through $c^1\ c\ c^3$ 42, in the reverse direction through the circuit and magnets $d\ d$ back to 43, and by c^4 to line."

The criticism of the *Engineer* upon this machine is as follows:—"Mr. Edison has probably succeeded in producing the very worst magneto-electric machine ever made—that is to say, if he has really ever constructed one according to his specification, which we much doubt. With a very little expenditure of space on our part, we hope to make this clear to our readers. Mr. Edison cannot imagine for a moment that the system of producing currents by magnets which approach to and recede from each other, as described, can be in any respect equal to that on which the Gramme, Siemens, or Lontin machines are based. It is, in fact, and for reasons which are well understood by all electricians, much inferior to the most defective of the machines we have named. Mr. Edison adopted the arrangement with the idea of reducing the power required to develope the electricity he needs. If we have two magneto-electric machines, one theoretically much less efficient than the other, it may nevertheless be practically the better of the two, provided it produces electricity with much less expenditure of power than its rival; and thus, although Mr. Edison might use his magnets and wires to great disadvantage, yet, if the power required to actuate them was very small, he would be justified in following the course he has actually adopted. But, in truth, Mr. Edison is entirely mistaken in his notions on this point. The fact that a tuning fork can be kept in vibration with the expenditure of little power has no more to do with the matter than the circumstance that the well-lubricated journals of a Gramme machine offer small resistance to the engine driving it. A strict analogy exists between the vibrations of a tuning fork and the oscillations of a pendulum. Now, if we substitute a pendulum for the vibrating bar patented by Mr. Edison, and fix an electro-magnet to its lower end, which, when the pendulum swings, will cut the field of a magnet placed just below it, we shall have a series of currents set up as the pendulum moves to and fro. Does Mr. Edison really imagine that a pendulum could under these conditions oscillate as freely and with as small an expenditure of power as if no magnetic apparatus were present, or does he fail to see the analogy between the tuning fork and a pendulum? If he does either, he must be ignorant of mechanical truths which are quite familiar to most men who have received any scientific training. The assumption that because a tuning fork vibrates with small expenditure of power when free, it will do the same when moving in a dense magnetic field, savours much of "perpetual motion." Mr. Edison may rest assured that in this way he will *not* "obtain a powerful electric current by the expenditure of a small mechanical force." Nothing is to be had for nothing under Nature's rule, and this law cannot be evaded, either by tuning forks or any other device. Let us suppose, however, that the Edison electro-magnetic machine was made. It is well known that to get the maximum power out of any such machine, the poles of the magnets and the armatures should approach as closely as possible. How can this end be secured without the use of fixed

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stops, against which the prongs of the fork shall strike? The stops must be placed just in that position which will permit the armatures and magnets to approach each other as closely as possible without touching. The effect of the hammering of the prongs on the stops may be imagined. Finally, the armatures ought to approach to and recede from the magnets not less often than 1,000 times in a minute. Does Mr. Edison really imagine that he can make a tuning fork "2 metres long" vibrate over sixteen times in a second? What is the engine to be like that will make sixteen strokes per second? Any attempt to work to Mr. Edison's specification would give a slow moving heavy machine, very much inferior to anything now in the market. We need say nothing more concerning this part of his invention. Figs. 2 and 3 show the lamp thus described in the specification:—

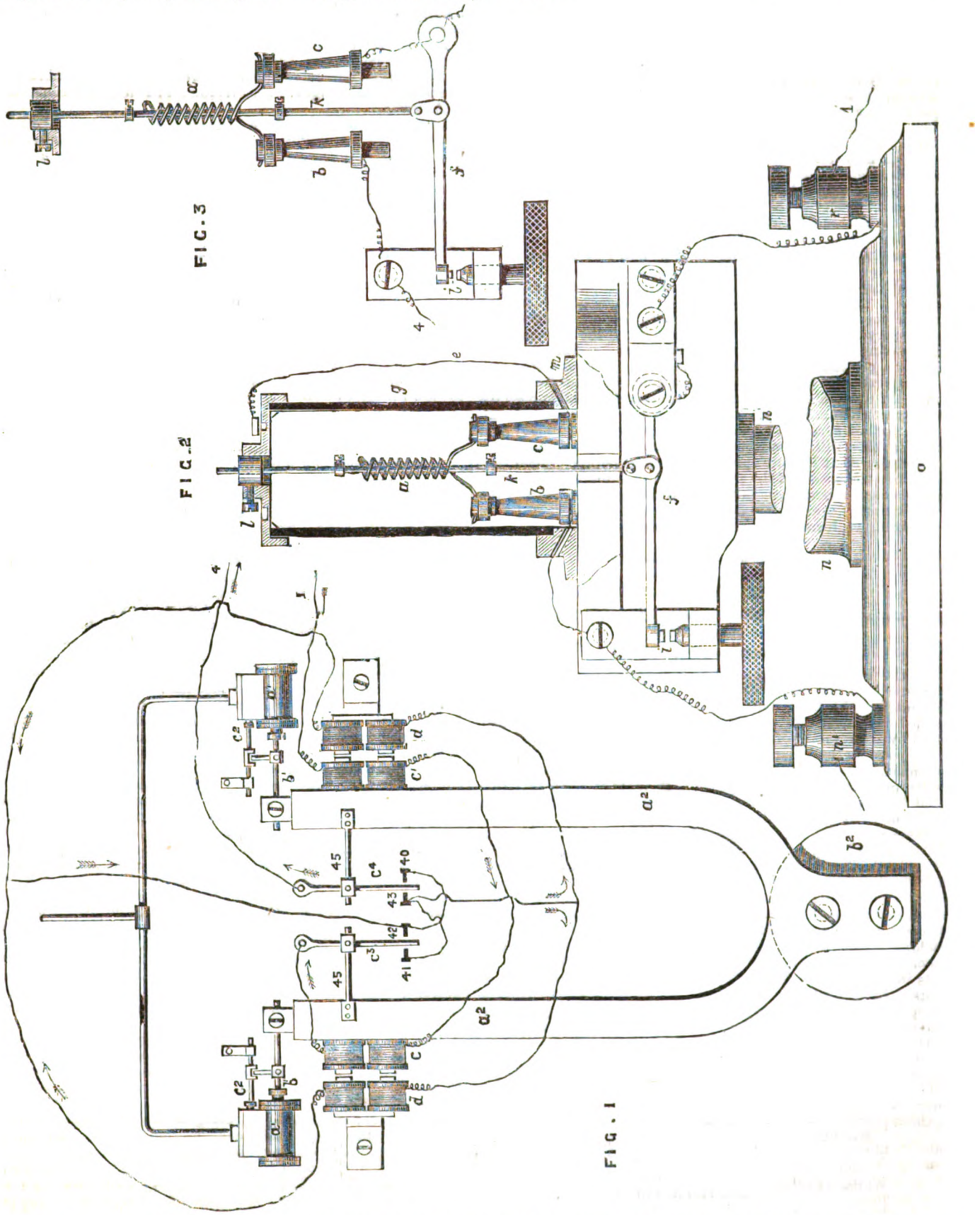

FIG. 3

FIG. 2

FIG. 1

"Platinum and other materials that can only be fused at a very high temperature have been employed in electric lights; but there is risk of such light-giving substance melting under the electric energy. This portion of my invention relates to the regulation of the electric current, so as to prevent the same be-

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coming so intense as to injure the incandescent material. The current regulation is primarily effected by the heat itself, and is automatic. In Fig. 2, I have shown the light-producing body as a spiral, *a*, connected to the posts *b c*, and within the glass cylinder *g*. This cylinder has a cap, *l*, and stands upon a base, *m*, and for convenience a column, *n*, and stand, *o*, of any suitable character, may be employed. Most of the other figures are in the form of diagrams to more clearly represent the electrical connections. I remark that it is preferable to have the light within a case or globe, and that various materials may be employed, such as alum water, between concentric cylinders to lessen radiation, retain the heat, and lessen the electric energy required; or coloured or opalescent glass, or solutions that reduce the refrangibility of the light, such as sulphate of quinine, may be employed to moderate the light, and the light may either be in the atmosphere or in a vacuum. The materials that I have found especially adapted to use as light-giving substances are set forth hereafter. The electric circuit, Fig. 2, passes by line 1 to the post *r*, and by a wire to the lever *f*, thence by the wire or rod *k*, cap *l*, wire *e*, to the post *c*, through the double spiral *a* to the post *b*, and by a metallic connection or wire to the post n^1 and line 4, and so on through the electric circuit, and the light be developed in *a*. The rod *k* will expand in proportion to the heat of the coil, or in proportion to the heat developed by the passage of the current through the fine wire *k*, and, if the heat becomes dangerously high, injury to the apparatus is prevented by the expansion of rod *k* moving the lever *f*, to close the circuit at *i*, and short circuit or shunt a portion of the current from the coil *a*, and reducing its temperature; this operation is automatic, and forms the principal feature of my invention, because it effectually preserves the apparatus from injury. The current need not pass through the wire or rod *k*, as the expansion thereof by the radiated heat from the coil *a* will operate the lever *f*, as indicated in Fig. 3, but the movement is not so prompt. It is to be understood that in all cases the action of the short circuit or shunt is momentarily to lessen the current through the light-giving substance, and the circuit-closing devices play up and down at the contact point, maintaining uniformity of brilliancy of light."

THE ELECTRIC LIGHT.*

By WILLIAM HENRY PREECE, M.I.C.E., V.P. Soc. T.E., Electrician General Post Office.

(CONCLUDED FROM PAGE 155.)

But the use of permanent magnets for the production of a magnetic field was supplanted by the use of electro-magnets. Siemens, in 1854, had produced an entirely new armature, which enabled electricians to considerably augment the currents produced by the rotation of a wire; and Wilde, in 1863, found that it was possible, by using the current produced in a small magneto machine to excite the electro-magnets of a much larger electro-magnetic machine, to produce currents of electricity that could be magnified enormously. In 1866 Varley, Wheatstone, and Siemens almost simultaneously showed how it was possible to dispense entirely with any permanent magnet, and make use of the residual magnetism contained in the passive iron, which, acting cumulatively, would produce currents of enormous strength. In 1870 Gramme, in Paris, constructed a machine on this principle, in which continuous currents in one direction were produced, and about the same time Hefner von Alteneck, in Berlin, improved on Siemens's machine in such a way as to produce a machine which is pre-eminent and nearly perfect. In 1877 Gramme produced another machine, producing alternate currents in opposite directions, to meet the wants of new electric lights. But of all the machines that have been produced in Europe, Siemens's, perhaps, remains *facile princeps*, while Gramme's machine runs it a very close second. In America two or three admirable machines have been invented, the best of which, and the only one of which we have seen in Europe, is the Wallace-Farmer machine, a very powerful and excellent one.

The following table gives a list of these machines, with measurements of the light produced by them per horse-power, as far as those particulars have been collected:—

Machine.		Light per horse-power.
Siemens		1,254 candles
Gramme		758 ,,
Wallace-Farmer / Brush	America about	400 ,,
Holmes (Alliance)		476 ,,
De Meritens		543 ,,

It will be seen that in recent years great advances have been made in the economy of the production of light by these machines, but the statements made by interested persons as to the power of the light produced by their machines must be taken *cum grano salis*, while the power consumed is almost invariably understated. The figures inserted in the above table have been gathered from two admirable reports; one made by Mr. Douglas and by Professor Tyndall, for the Trinity House, and the other made by a committee for the Franklin Institute, in Washington.

It is worthy of note that Sir William Armstrong, at his residence near Newcastle, has utilised the energy of a waterfall to produce these currents, which are brought into his library for the production of light. Mr. Wallace has done the same thing in America.

Now, it has been stated that the heat generated by a current can be utilised for illumination, first in the form of incandescence, and, secondly, in the form of the arc. The first form of incandescence is that assumed by a fixed wire of given length when a current of given strength is passed through it. In 1844 Dr. Draper, of New York, utilised this principle in the way that has been described in the earlier part of these notes, and from that day to this the patent lists of both America and England are full of the names of those who have endeavoured to utilise the same principle by using either platinum, an alloy of platinum and iridium, or carbon, so as to make it available for lighting purposes. The latest and best form is probably that shown by Werdermann, whose light is remarkably steady, though requiring a considerable expenditure of power to produce it.

Dr. Tyndall has shown that the visible rays of an incandescent wire bear to the invisible rays a much smaller proportion than in the arc, and it is generally assumed that for the same current the arc will give at least 2½ times greater light than an incandescent wire; in fact, Dr. Tyndall's figures are as follows:—

	Visible rays.		Invisible rays.
Gas	1	to	24
Incandescent Wire	1	to	23
The arc	1	to	9

But the ease with which a wire can be maintained incandescent has led many to believe in the possibility of the extreme subdivision of the light. There is, however, no difficulty in showing that this hope is quite inadmissible, according to our present knowledge. There is, however, one point in which it may be possible to make use of an incandescent body for light-giving, and that is in the case of iridium. The fusing-point of that metal is almost beyond measurement, and were it possible to produce currents strong enough, there is no doubt that a bright, steady, brilliant light would result from its use. One of the grandest features in Dr. Tyndall's lecture at the Royal Institution on the electric light was the brilliant glow produced in incandescent iridium by the Wallace-Farmer machine.

The electric arc is to all intents and purposes a little sun. We have in it the production of intense heat and the transference of particles of carbon, raised to incandescence, across the air space.

When the two carbons are placed in contact with each other, we have a species of microphonic effect. They make a "bad contact," heat is generated, the air is practically rendered a conductor, the incandescent matter is transferred across this space, and we have not only the production of intense heat and light, but we have the transference of matter from the positive to the negative carbon. Hence we have one of the carbons consumed at a greater rate than the other, and thus the light does not remain a fixed point in space. It was soon found that some species of regulator was required to keep the point of light always in the same place. This was effected by Foucault in 1848. He gave the two carbons a motion equivalent to the rate at which they were consumed. Serrin improved on this, and the forms of lamps based on this principle are almost innumerable. The only real departure from the principle introduced by Foucault of any practical value is that of Wallace, who places two plates of carbon opposite to each other, the distance apart being regulated by the attraction of an electro-magnet.

These forms of regulators, as a rule, require the addition of complicated machinery to maintain the unequal motion of the points of the carbon, but Jablochkoff in 1876 made a move in an entirely different direction. He placed his two sticks of carbon side by side, separated from each other by a layer of insulating material, and, by using alternate currents, he was able to produce an equable consumption of the carbons, and thereby dispense altogether with the complicated machinery such as that introduced in the Serrin lamp. Although this "candle" was introduced by M. Jablochkoff, it in reality had been previously invented by Mr. Werdermann. M. Rapieff also has made a distinct departure on this line, and has produced an exceedingly simple lamp. It is impossible to refer to all the lamps that have been introduced. The writer prefers to confine his attention to those which have been practically under trial.

The requirements of a good electric lamp are, first, intense

* Lecture at the United Service Institute.

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brilliancy; secondly, great steadiness; thirdly, duration. The Serrin lamp has the first kind of excellence; all those lamps based on incandescence excel in the second respect; the Wallace-Farmer light is the only one that attains the third point. The Rapieff is, perhaps, that form which up to the present most nearly combines the three requisites, but in reality no lamp has yet been introduced which fulfils all three requirements.

The objections to the use of the electric light are :—

1. The deep shadows it throws.

2. The indifferent carbon that has hitherto been manufactured for the purpose, which leads to unpleasant sounds, to great variation in the intensity of the light, and to waste.

3. The difficulty in distributing the light itself. It is so intense and confined to so small a space that it does not lend itself to distribution like the gas flame, which occupies a considerable space.

4. The unsteadiness of the light due to variations in the speed of the engine employed in driving the dynamo machine. There is another cause of variation in the electric arc, and that is, the variation in the resistance of the arc itself, for it has been clearly demonstrated by experiments both in America and in England that the resistance of the arc varies as the resistances in circuit vary. The following table will show this :—

Current in Webers.	Light candles.	Resistance of arc. Ohms.
10	440	2·77
16·5	705	1·25
21·5	900	1·67
30·12	1,230	·54

The light in the arc varies directly as the current, and not as the square of the current as is generally assumed.

Now, in the case of light raised by incandescence, the light will increase as the square of the current. It follows that if in the one case, viz., the arc, the light increases as the current only, and in the other case, viz., incandescence, it increases as the square of the current, a point is reached when the light produced by incandescence will equal that produced by the arc. The difficulty in reaching that point is the difficulty in obtaining a conductor with a sufficiently high point of fusion to resist the effect of powerful currents. Iridium is the only metal that is known to do this, and iridium is too scarce and too dear to be used for the purpose.

The multiplication of the light by Gramme's machine upon the Thames Embankment must not be taken as the solution of the problem of the subdivision of the light. Theory shows unmistakeably that to produce the greatest effect we must have only one machine to produce only one light. We know from absolute measurements that such a machine can be used to produce a light of 14,880 candles, and it is possible to produce 1,254 candles per horse-power; but the moment that we attempt to multiply the number of lights in circuit this power diminishes, so that we have on the Embankment lamps giving us a light of scarcely more than 200 candles. The light of the Rapieff lamp in *The Times* office appears to be about 600 candle power, and the Wallace light is equal to 800 candle power. In these two instances six lights are used in one circuit, but we have not here the subdivision of the light; we have, on the contrary, the multiplication of the light, produced by the increased speed of the engine, due to the insertion of additional lamps. It is, however, easily shown that in a circuit where the electromotive force is constant, and we insert additional lamps, then when these lamps are joined up in one circuit, *i.e.*, in series, the light varies inversely as the square of the number of lamps in circuit, and when joined up, as in multiple arc, the light diminishes as the cube of the number inserted. Hence the subdivision of the light is an absolute *ignis fatuus*. In the first place no machine has yet been produced which is competent or capable of lighting over 20 lamps; secondly, no conductor is known but copper competent to convey the current required to light these lamps, and copper is an expensive material. Thirdly, no electric light has yet been produced which combines all the criteria needed for a good light.

As to the cost, all that we have seen in print is problematical and one sided. Invariably the estimate of the light-producing power is too high, and, as has been previously stated, the expenditure of power is put at too low a figure, so that we have not yet received authentic information as to the cost of the light.

The electric light is unquestionably a wasteful form of energy for the production of light, because we cannot utilise all the heat produced, but only a fraction of it. Under the most favourable circumstances this fraction is but a half, and we can therefore never utilise more than that. But it has shown us what a good light is, what it ought to be, and how it should be obtained. Although the extensive subdivision of the light must be ranked with perpetual motion, squaring the circle, and the transmutation of metals, yet no one will say it is "impossible," but all must say "not yet." Science itself is ever moving, new discoveries are ever coming to the front, and although it would almost seem that in the electrical world discovery had ceased, nevertheless it is impossible to say from day to day what the morrow may bring forth. New discoveries may lead to new applications, and new methods may lead to new developments, but though we hesitate to say it is impossible, yet it would seem in our present knowledge that electricity cannot supplant gas for domestic purposes. For lighting large spaces, workshops, warehouses, railway stations, docks, extensive areas where work is being conducted, for naval and military purposes, for guarding ships and fortresses by night, it seems admirably adapted. Whatever the electric light of the future may be it will have its own sphere. While the introduction of gas in no sense or form interfered with the production of candles, so it is difficult to perceive that electricity will in any way interfere with gas. It will, on the contrary, rather tend to increase its consumption by giving us a greater appetite for a better light.

THE PHYSICAL SOCIETY.

*On the Determination of the Variation of the Thermal Conductivity of Metals with Temperature, by means of the permanent curve of temperature along a uniform thin rod heated at one end in vacuo.**

BY OLIVER J. LODGE, D.SC.

The absolute conductivity of wrought iron, and its rate of variation with temperature, have been investigated by Principal Forbes by a perfect, but excessively laborious, method of graphical and empirical computation from observed curves of temperature down large iron rods heated at one end. The discussion of the results in this manner is so formidable that no one appears yet to have applied the method to other metals, at least with anything like the same care. At the same time, it is a most important research to observe whether the law of variation is the same for thermal as for electrical conductivity.

The first approximation to the theoretical curve of temperature employed by Biot, by Despretz, and by Wiedemann and Franz, viz., that it is a logarithmic curve, is very inaccurate when large ranges of temperature are employed, and, as Forbes showed, is then almost useless. It is obtained from a simple differential equation, $\frac{d^2t}{dx^2} = \frac{Hp}{Kq}$, on the hypothesis that H is proportional to t (Newton's law), and that the other quantities are constant. As a matter of fact, however, they are all variables, and can at the present time be expressed with considerable accuracy as empirical functions of the temperature; H, from sundry experiments on the law of cooling, and K in a provisional manner, with the constants undetermined except for iron and copper, from the experiments of Forbes and also of Angström.

It, therefore, seemed well to try and obtain the integral of the above equation after expressing all the pseudo-"constants" as functions of t. And this is the object of the Paper, and it has been accomplished for a rod in a vacuum. The result is a much closer approximation to the true curve of temperature; and from the equation to this curve the author believes it to be possible to extract from future experimental results, in which temperatures are very accurately observed, over a considerable range, on rods of different metals in vacuo, not only their relative conducting power at zero centigrade, but also its rate of variation with temperature.

The calculation has been made in view of a modification of Wiedemann's thermoelectric method of observing the temperatures contrived by Professor G. C. Foster, and which the author believes to be capable of giving exceedingly accurate results.

The mode in which the desired quantities are ultimately obtained is as follows:—

Observe temperatures θ_1, θ_2, θ_3, &c., all down the rod at equal distances, ϵ; then the following relation holds:

$$\frac{\frac{1}{\theta_1} + \frac{1}{\theta_3} + 2\lambda}{\frac{1}{\theta_2} + \lambda} = \text{const.} = \cosh. \mu\epsilon.$$

From a number of such observations the constant λ can be calculated, and it expresses the law of variation of conductivity with temperature. The whole constant being thus known, μ is readily obtained, and this is inversely proportional to the square root of the conductivity at zero centigrade. To obtain the *absolute* conductivity, direct experiments must also be made on the rate of cooling of the rod under the actual conditions of the experiment.

* Abstract of a Paper read at the meeting of the Physical Society of London on the 8th February, 1979.

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LITERATURE.

Nickel-Plating: Its History and Useful Applications, with Remarks on the Dynamo-Electric Machine.

This pamphlet, issued by Mr. William Elmore, of 41, Queen Victoria-street, contains several items of information, which may be of importance to those who take an interest in Nickel-Plating, and will be specially welcomed by the student who has turned his attention in this direction. The days of difficulty in obtaining a nickel anode, the days of discouragement by reason of the impurity of such anode, and the consequent imperfection of the deposited coating, have gone for ever. "To make the *amende honourable* for having patented and sold to us one of our own published processes," says Mr. Elmore, "the Americans have been good enough to turn their attention to the refining of nickel; and the result is that they can, and do, send into this country nickel anodes almost absolutely pure, and of small and large sizes, to meet the requirements of their English cousins." Mr. Alexander Watt, whose name brings back to us the time when, mainly under his guidance, we mastered one by one the first difficulties in obtaining metallic deposits by electrolysis, testifies to the extreme whiteness and beauty of the coating produced by Mr. Elmore through the use of such anodes, and solutions perfectly free from iron or other metallic impurity. We are informed that the finest quality American nickel solution can be obtained for 5s. per gallon, and that such solution is now generally made by the use of the dynamo-electric machine, "which enables us to dissolve nickel and other metals in their various solvents, far more economically and in greater purity than by the ordinary method of treating metals." The Weston dynamo-machine, which appears to be that most generally approved of by electro-platers, is used and recommended by Mr. Elmore, whose pamphlet may be obtained on application at the address given above.

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).

The fifteenth ordinary general meeting of the above Company took place on Wednesday, the 19th inst., at the offices, Old Broad-street, under the presidency of Mr. Thomas Hughes, Q.C., the Chairman of the Company.

The Deputy-Secretary read the report, an abstract of which appeared in *The Electrician* of last week.

The Chairman, in moving the adoption of the report and accounts, first alluded with very deep regret to the sudden death on Sunday last of the chief officer of the Company. Mr. Brand, who had been their secretary and manager from the establishment of the Company ten years ago. He was sure that the shareholders would regret his decease as deeply as the directors did. They would do their best to supply his place as worthily as possible. With respect to the affairs of the Company, the business was almost precisely what it was in the previous year, so the ordinary increase which might fairly be expected in the business of telegraph companies had consequently not been realised. The gross earnings were almost the same—a few hundred pounds less than those of 1877. The cause of this was that during the whole of the past year the Government land lines had been working in competition with the Company's line. Owing to this there had been a decrease of 2,000 local messages, or something like 16 per cent. of the total local business. This, however, need not be regarded as a loss, because the increase of the through business—on which, of course, they relied more than on the local business, had just about made up the balance, and practically the receipts had thus been kept up to the total of the previous year. In the future they could not look for any great increase in their local business, unless they saw their way to such a reduction of the tariff as would enable them to compete successfully with the local lines, but the policy of making any such reduction was exceedingly doubtful, as the greater part of the local business they had lost had practically been the Government messages, which would not be affected by a reduction on the Company's lines, as the Government would use their own lines in any case. As to the question of dividend, they had recommended one at the rate of only 6 per cent. per annum on the ordinary shares, and he thought that, considering the state of their property in the West Indies, they would all be of opinion that that dividend was quite as much as they could prudently declare on the present occasion. That time last year several shareholders expressed the opinion that the Company could have quite fairly declared a larger dividend, and they founded their views as to the amount of the dividend which should be declared upon the fact of the vastly improved condition of the cable. Mr. Hooper, too, whose knowledge made him an authority on such a subject, argued as a reason for the dividend being increased that the "life" of the cables would prove to be considerably longer than the estimate adopted by the Board. He, however, thought the experience of the past year had shown that the policy of limiting the dividend was a wise one, because it seemed to show that the "life" of the cables, so far from being longer than the Board estimated—10 years—was likely to prove shorter; and they had also had the misfortune to have again to undertake the repair of faults in their cable. That morning they received a telegram from their manager at Jamaica—who was now engaged in the repair of the cable—to the following effect:—"Picked up cable; lost the Santiago end, and buoyed the Cienfuegos;" so they might expect almost immediately to hear that the first portion of his work had been satisfactorily performed. Until, however, the whole of the work had been completed they could not ascertain what the expense would be with any certainty, and therefore they recommended the dividend mentioned, and that the whole of the balance of £4,053 should be carried forward, so that they might be enabled to pay the expenses out of it. The decree of the Court of Madrid, as to the tax imposed by the Spanish Government upon the local business of the Company, had been received, and the result was that the claim of the Company had been to a great extent allowed, and about £1,200 would have to be returned to them by the Spanish Government. He concluded by moving the resolution.

Mr. Alexander F. Low seconded the motion.

Mr. John Newton and Mr. Griffiths dissented from the Chairman's view as to the "life" of their cable being only 10 years. A well-manufactured cable, laid properly and on favourable ground, would live practically for an indefinite period—certainly 30, 50, or 100 years.

The Chairman, in reply to questions and observations, said that negotiations were going on as to the Para cable, and they trusted that the connection might be made with South America, which would be of immense advantage to this Company. The opinion of the Board as to the "life" of a cable was of no more value than that of other persons connected with telegraph business, but they had only to look to facts as connected with their own business; and although he admitted that their experience might be exceptional, he did not think they would be justified in treating their cable as likely to have an undisturbed "life" of more than 10 years. Experience showed that the West Indian seas were not favourable to the "life" of a cable. As to the remarks about the defective nature of the last cable laid for them, the india-rubber cable, it had been constantly under the consideration of the Board whether there was any fault attributable to the manufacturer, but it was impossible for them to ascertain whether the fault lay with, and could be brought home to, the manufacturer or not till the fault was reached. The cable, however, was constantly inspected and severely tested during its manufacture by Mr. Keith, who was now repairing it.

The motion was then unanimously adopted, and the dividends having been declared, a vote of thanks to the chairman and directors terminated the proceedings.

RECENT PATENT.

2385. Electric Telegraphs, *E. A. Cowper.—Dated 15th June*, 1878. 6*d*.

A sending instrument employed at one station consists of a pen moved to trace letters or figures on a moving paper surface; and at the other station another tracer is employed so as to produce similar characters as those traced at the sending station. The sending tracer moves two contact makers, the one in a line at right angles to the line of the other. Each contact maker moves over a set of stepped conductors, so as to send into line currents of greater or less force, according to the extent of the movement. By one contact maker the current is sent into one of two lines which connect the sender to the receiver, and by the other contact maker currents are sent into the other line. At the receiving station the tracer is moved in two directions, at right angles to one another, by means of polarised armatures. One instrument is actuated by the currents sent into the one line, and the other by the currents sent into the other line.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices Feb. 19.		Business Done Week Ending Feb. 19. Highest.	Lowest.
Anglo-American	58½, 59		59½	58½
Do. "B"	86½, ¾		86¾	86½
Do. "A"	31½, ¾		31¾	31½
Brazilian	6½, 7		6 15-16	6½
Cuba	8¼, ½		8½	8¼
Do. Ten per Cent. Preference	15½, 16		—	—
Direct Spanish	1½, 2		—	—
Do. Ten per Cent. Preference	10, ½		—	—
Direct United States	11½, ¾		11¾	—
Eastern	7 5-16, 7-16		7½	7¼
Do. Six per Cent. Debenture	104, 107		106	105
Do. Five per Cent. do.	100, 103		—	—
Do. Six per Cent. Preference	11½, ¾		11½	11¼
Eastern Extension	7 5-16, 7-16		7⅜	7 3-16
Do. Six per Cent. Debenture	105, 108		—	—
German Union	7⅜, 8¼		8¼	7⅜
Globe Telegraph and Trust	4 15-16, 5 1-16		5¼	4 15-16
Do. Six per Cent. Preference	10 7-16, 9-16		10¾	10½
Great Northern	8¼, 8½		8¾	8 3-16
Indo-European	20, 21		—	—
Mediterranean Extension	2¾, 3¼		2¾	—
Do. Eight per Cent. Preference	9, ¼		9	—
Reuter's	10, 11		—	—
Submarine	215, 225		223	219
West India and Panama	1¾, 2¼		2 1-16	2
Do. Six per Cent. Preference	8¼, ½		—	—
Western and Brazilian	4, ¼		4 1-16	3¾
West. Union Seven per Cent. 1st Mort.	114, 118		115¾	—
Do. Six per Cent. Sterling	102, 104		—	—

TRAFFIC RECEIPTS FOR JANUARY, 1879.

Companies.	Jan. 1879.	Jan. 1878.	Increse.	Decrse.
Cuba Submarine Company	2,900 estd.	3,001	—	101
Direct Spanish Telegraph Company	951	944	7	—
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	24,695	22,905	1,790	—
Eastern Telegraph Company	39,226	41,531	—	2,305
Great Northern Telegraph Company	13,856	13,511	345	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company.	2,125	1,725	400	—

SUN ELECTRIC LIGHT COMPANY (LIMITED).

The Company are now prepared to entertain APPLICATIONS for ILLUMINATING all descriptions of PUBLIC BUILDINGS, PROMENADES, STREETS, MILLS, SHOPS, MINES, &c., by their Patent Process. All inquiries to be made at the Offices, 68, Cheapside, London, E.C.

J. P. BEDFORD, *Secretary, pro tem.*

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NOTES.

CABLE MANUFACTURE.—The Construction and Maintenance Company manufactured 2,631 miles of cable during the past year.

MAGNESIUM AS A POSITIVE ELEMENT.—A pound of magnesium will generate nearly three times as much electricity as a pound of zinc.

ABSORPTION OF HYDROGEN BY METALS.—Platinum will absord 2·19 volumes of hydrogen, whilst iron will absorb only 0·57, or rather more than half its own volume.

THE WORKING MEN'S COLLEGE.—On Thursday, March 6th, the lecture will be "A Talk about Telegraphs," by Sir J. Anderson. We may notice that admission to these popular lectures is free.

SOCIETY OF TELEGRAPH ENGINEERS.—On Wednesday evening, the 26th February, Mr. Cowper contributed a paper on his Telegraph Writing Apparatus before this society. We hope to fully describe and illustrate the apparatus in our next issue.

TASMANIA.—At the commencement of last year this colony had in work 850 miles of telegraph line, with 1,000 miles of wire, with forty-six receiving stations. The cable connecting it to Australia carried over 12,000 messages during the previous year.

THE WERDERMANN ELECTRIC LIGHT.—We are informed that five of these lights are to be established in the reading room of the South Kensington Museum, and that this light is to be adopted at the Enfield Small Arms Factory as well as in Woolwich Arsenal.

THE SOCIETY OF TELEGRAPH ENGINEERS.—Our attention has been drawn to the fact that in our report of the meetings of this society we have unintentionally called the President Major Champain. The gallant gentleman was recently gazetted Lieut.-Colonel.

THE ANGLO-AMERICAN TELEGRAPH.—The Brest cable was broken on Saturday morning, 22nd February, during a violent storm, about 161 miles from St. Pierre, in 500 fathoms of water. The company's ship has been ordered to proceed to sea at once to effect the repair.

GREENWICH TIME SIGNALLING.—In Glasgow nearly 100 clocks are now synchronised and kept to Greenwich time, by means of electrically connected wires between the respective clocks and the Glasgow Observatory, which is in direct communication with Greenwich every hour.

PROFESSOR GRAHAM BELL AND THE TELEPHONE.—In Mr. G. B. Prescott's new work, "The Speaking Telephone, the Electric Light, and Other Recent Electrical Inventions" (Spon, London), Professor Bell's claims as the inventor of the telephone are directly challenged by Mr. Elisha Gray, who is evidently supported by the editor himself.

DELAURIER'S EXCITING FLUID FOR BATTERIES.—This solution consists of twenty parts of protosulphate of iron in thirty-six parts of water, seven parts of sulphuric and one part of nitric acid. It attacks zinc and iron without any evolution either of hydrogen or of nitric peroxide, and possesses the property of absorbing fresh quantities of oxygen when exposed to the air.

IRIDIUM.—According to M. Becquerel a Mr. Children succeeded in fusing iridium to a white globule, very brilliant, yet porous, by means of a very powerful battery. Who was Mr. Children, and where can the records of his experiments be found? They would undoubtedly be interesting at this time when the substance has been noticed so prominently in connection with the electric light.

ELECTRIC LIGHT.—Sir J. Anderson has induced Mr. Latimer Clark to deliver a very interesting lecture, illustrated with experiments, on the electric light, in aid of the funds of St. Saviour's Church, at the Eyre Arms Assembly Rooms, on Wednesday evening, 5th March, to commence at eight o'clock. Tickets can be obtained on application to 16, Warrington-crescent, Maida Vale, 2s. 6d. and 5s. each.

THE TELEPHONE AND THE TORPEDO.—M. Marey, who is known as a physiologist, has been studying by means of the telephone the electric discharge produced by certain fish. He finds that, with suitable arrangements, the torpedo produces the note *mi* of 183 vibrations. This result coincides exactly with that already obtained by means of the graphical method, which necessitates the use of delicate and cumbrous apparatus.

M. DU MONCEL AND MR. CROOKES.—M. du Moncel points out that the dark space observed by Mr. Crookes in the induction spark in vacuo, exists also in the spark under more ordinary conditions. When an induction spark, for example, says M. du Moncel, is passed between two pieces of glass, and examined with the microscope, a beautiful violet light extends out from the positive, and the dark space seems to shape itself on the contours of the negative electrode.

CITY POSTAL IMPROVEMENTS.—A new and spacious branch post office in Charterhouse-street, in lieu of the office which formed a portion of the bank buildings in St. John-street, has just been erected on the opposite side of the way. The new office is conveniently arranged for all descriptions of postal and telegraph business, and is connected with the Central Telegraph Office by means of a pneumatic tube. It will be open for telegraph business from 7 a.m. till 8 p.m.

ELECTRIC LIGHT IN PARIS.—According to the *Journal des Usines à Gaz*, the Municipal Council decline the offer of the Compagnie Générale d'Electricité to light a more extended area of Paris for 60c. per lamp, but offer 30c. per lamp, which is, the Council thinks, 7c. more than it is worth. As the company estimate that it costs them 73c. per lamp, they would lose 13c. if their own offer were accepted, and 33c. if they accept that of the Council. The Jablochkoff is the light exclusively used by the company referred to; and it appears that the extinctions from one cause or other during

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four months last year were no fewer than sixty, four lamps, and sometimes as many as sixteen, going out at one time.

British Association.—It is intended to make a special effort to issue the Sheffield report at an early date after the meeting. To enable this to be done, the council request that all reports and abstracts of all papers intended to be read in the sections may be sent to the assistant secretary not later than July 15, in order that, if approved of by the organising committees, they may be put in type before the meeting. Authors who comply with this request, and whose papers are accepted, will be furnished *before* the meeting with printed copies of their reports or abstracts. No report, paper, or abstract can be inserted in the volume unless it is in the assistant secretary's hands *before the conclusion of the meeting.*

Effects of Magnetisation.—Ever since Joule's experiments with electrically magnetised soft iron bars, it has been an accepted axiom that elongation takes place; in other words, that the change is in the shape, but not in the volume of the bar. If we rightly understand the results of Professor Hughes's recent experiments, they tend to show that this notion is erroneous; and we think it desirable to again direct attention to his statement. He says, "On one end of a bar magnet with its coil a microphone was attached, so as to be influenced only by its elongation, and no sounds whatever were heard, although it was sensitive to a hair lightly drawn across the pole." This mode of using the microphone was suggested in these columns some time previously, and similar results predicted. As a detector of minute motion, molecular or mechanical, the microphone has not yet been used as freely as it deserves to be.

Effect of Magnetism on Polarised Light.—M. Henri Beqnerel recently made an experiment which seems to open out a new horizon to science. Two rays of light, polarised in the same direction, are each passed through a lens of flint glass. The two glasses are subjected, in opposite directions, to the action of an electro-magnet, as in the experiments of Faraday. At their exit the two rays are brought into interference with each other. Now it is observed that the passage of the current has the effect of displacing the fringes, and this displacement is reproduced in an opposite direction when the current is interrupted. It may be concluded from this result that the magnetic rotation of the plane of polarisation is due to the same cause as the phenomena of circular double refraction observed in quartz, and all will appreciate the importance of this conclusion.

Experiments with the Electric Light at Liverpool.—Last week a series of experiments were made with the electric light at the George's pier head, Liverpool. The experiments were carried out by the British Electric Light Company (Limited), who erected a shed for the accommodation of the necessary engine for the generation of the electric power, and placed above the ordinary triple lamp facing the floating bridge leading to the landing stage a large lantern, in which were two burners. The generator was one of the Gramme machines, and the motive power was supplied by one of Messrs. Cochrane and Co.'s multitubular boilers and vertical engines. A very brilliant ray of light was thrown along the floating bridge, and, notwithstanding the somewhat hazy state of the atmosphere, penetrated far over the river, proving beyond doubt the utility of the light either for signalling or for penetration of fog. The effect upon the ordinary gas lamps in the vicinity was very peculiar; the burners appeared as dim as rushlight candles, and, excepting in the immediate rays of the electric light, the locality seemed to be enshrouded in gloom. The management of the experiments was under the care of Mr. Radcliffe Ward, electrical engineer to the British Electric Light Company and Mr. Alderman Hubback, the chairman of the company.

The Electric Light at the British Museum.—For some time past statements have been made as to trials of the electric light in the reading room of the British Museum, but these statements were premature, for it was not till this week that the arrangements for the experiments were completed. A Gramme machine and Jablochkoff candles are used, the one to produce the current, the other to give light. We are a little surprised at the continued use of this candle, inasmuch as every report of any value yet given has been decided as to its cost. If there were no other light this use might be excusable, but its costly nature can be used as a strong argument against the introduction of the electric light in many places where it would otherwise be tried. In the Museum the lights are some fifteen feet above the floor, and placed alternately at the end of the passages which radiate from the centre of the room. There could be no doubt whatever as to the success of the experiment. One could see to read in any corner of the hall with the greatest ease. On a future occasion a larger number of lamps will be tried, but if an increase in the illuminating power is required, without adding to its cost, it might be obtained by employing globes which do not obscure the light so much as those used on Tuesday last.

The First Experiences of the Japanese with Statical Electricity.—We take the following from Mr. E. Clark's "Life and Adventure in Japan." The author lived in Japan from 1871 to 1875, and was in the service of the Japanese Government. He describes the Japanese as being very fond of anything practical, and as being delighted with anything in the shape of experiment, even, apparently, when practiced upon themselves:—"I never witnessed a more ludicrous sight than the effects produced upon the Japanese by some of my experiments. The innocent manner in which they stepped up to the various electric machines, and did whatever they were told, was only excelled by the dumb astonishment or the frantic yell with which they received the electric shock. No visible effect, however great, upon the first who wanted to take hold was sufficient to restrain the intense curiosity of those who wished to follow. They wanted to feel for themselves, and their ambition was usually satisfied after one trial. Two of the governors took a 'spark' from one of the machines, but the third was very dignified, and would not deign to come up to the table, as it was contrary to strict etiquette. So I politely offered to bring him some electricity in a bottle. He doubted whether that could be done. In order to dispel his doubts, and also to bring him down to the level of ordinary mortals, I took a large Leyden jar, which I charged full of electricity, and brought it to him with good grace. He looked at the jar, and seeing nothing in it, concluded to touch the brass knob at the top. The effect may be better imagined than described, only he didn't show any more dignity or touch any more jars that day!"

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FOUR LECTURES ON ELECTROSTATIC INDUCTION.

JAN. 16, 23, 30, AND FEB. 6.

BY J. E. H. GORDON, B.A.

(Assistant Secretary of the British Association).*

LECTURE II.—JAN. 23.

To-day we will continue our inquiry as to the reasons for supposing induction to be a state of strain, and we will now attempt to obtain an answer to this inquiry from a study of the various phenomena exhibited by the instrument known as the Leyden jar. The Leyden jar, in its most common form, consists of a wide-mouthed bottle, coated inside and out with tinfoil. The wooden stopper supports a brass knob, which communicates, by means of a wire or chain, with the inside coating. In order that the inside and outside coatings may be well insulated from each other, they do not reach quite to the top of the jar. Thus the jar forms a system of two conductors (the tinfoils), separated by a thin insulator (the glass). If we connect the knob of the jar to the machine and work the latter, we can charge the inside tinfoil, and, on removing the machine, this tinfoil will retain its charge for a considerable time, as is shown by this electroscope on the knob. This insulated electrified conductor now acts by induction through the glass of the jar, and induces electricity on the outer tinfoil conductor. As long as the jar is insulated, there will be negative electricity on the nearest portion of this outside conductor—that is, the inner surface of the outside tinfoil—and positive electricity on the further or outer surface. Now, let us, as before, remove the other end of the outer conductor to the other side of the world by connecting the outer coating to the water pipes; we shall then have the whole of the outer tinfoil negatively electrified. Here, then, we have our two conductors oppositely charged, acting on each other inductively through the glass. Some idea of the intensity of the strain may be obtained by "discharging" the jar, as it is called. I have here a pair of what is called "discharging tongs," which consist of a conveniently-shaped conductor fixed to an insulating handle. I hold the "tongs" so that one knob touches the outer conductor of the Leyden jar, and then bring the other knob of the "tongs" near the knob of the jar, which, we remember, is connected to the inner coating. The strain between the conductors is now taking place through two different insulators; that is, first through the glass of the jar, second, through the air between the two knobs, viz., the knob of the jar and the upper knob of the tongs. The glass is strong enough to resist the straining force of such a charge of electricity as the jar now has. We now bring the knobs nearer together. The straining force across the air between them gets greater and greater, and, at the same time as the thickness of the air diminishes its power of resistance, or of sustaining the state of strain, gets less and less, till here, as you see, the air breaks and gives way, and the electricities rush together with a flash and a report. The straining force of the charge which we gave to the inner coating is removed with the charge, and immediately after the flash and discharge the falling of the electroscope shows that there is no electricity whatever on either coating of the jar. But, see, now the electricity seems to be returning; the slight motion of the electroscope ball shows that a slight charge has returned to the inner coating. On applying the discharging tongs a spark occurs as before, only it is very much feebler, and the jar is now completely discharged. What does this mean? Where did the second charge of electricity come from? Let me show you a mechanical experiment, which will help us to an explanation. I have here a strip of gutta percha, of which the lower end is fixed to a block. As it is somewhat small, I will turn it edgeways to the lime light, and project the shadow of it on the screen. I now bend it down by my finger, and suddenly let it go. It flies up nearly, but not quite, to the vertical position, rests an instant, and then moves slowly on till it is quite vertical. If a spring index had been applied to it, it would have been seen that while pressed down it exercised a strong upward pressure. At the moment when it was at rest a little way from the vertical it would be exercising no pressure, and then it would be seen that as it began to again move towards the vertical, it would again exercise pressure. The gutta percha was strained or distorted by the finger. When the straining force was removed, the strain nearly disappeared suddenly, but not quite. Then, in the course of the next few minutes, the disappearance of the strain or distortion was completed slowly. The electrical case is exactly analogous. The pressure of the finger represents the first charging of the inner tinfoil, the straining of the gutta percha represents the electrical straining of the glass. The pressure on the finger by the strained india-rubber represents the induction on the outer conductor and the electroscope which forms part of it. As in the gutta percha, when the straining force is removed, the strain or distortion nearly disappears, and the upward pressure exercised by it entirely ceases, so in the Leyden jar, when the inducing electricity is taken away, the strain of the glass almost vanishes, and the induced charge disappears. The strain or distortion of the glass, however, has only almost, but not entirely, disappeared; and now that there is no straining force interfering, the particles of the glass move over each other slowly, and in the course of a few minutes return to their normal state. But now, while the inner conductor has remained insulated, a change has occurred in the electrical arrangement of the particles of glass adjoining it. The state of strain has altered. They have changed from a more to a less distorted shape. Now, in the ordinary phenomena of induction, what happens when we alter the state of strain of an insulator by bringing a charged body near it? Why, it induces electricity on any adjoining conductor. Similarly in the present case, when the electricity of the glass brings it from a more to a less strained state, and so alters the state of strain, a change is produced on the insulated conductor, and this is the residual charge which we have been inquiring about. We notice that this residual charge returns slowly and gradually. Now, when a body is mechanically distorted, and is returning to its normal state by virtue of its elasticity, anything which enables the particles to move more freely over each other, such as tapping or jarring, will hasten that return. If, for instance, we have a heaped up tray of sand slowly returning to its normal unstrained state of being level under the action of gravitation, and tapping of the tray will hasten the recovery from the state of strain; that is, hasten the return of the surface to a level state by enabling the particles to slide more freely over each other. Now, if our supposition that these induction phenomena are the effects of strain, and that the residual charge is the returning of the distorted particles of glass to their normal state, is correct, any tapping or jarring of the glass should hasten this return; that is, hasten the appearance of the residual charge. In the *Phil. Trans.* for 1876 Dr. Hopkinson has shown that this actually occurs, and I shall now hope to repeat his experiment before you. For this purpose we will not be content with our electro*scope*, but, as we wish to measure electrification, we must use an electro*meter*. The instrument here is called the quadrant-electrometer, and is the invention of Sir William Thomson. We will not here attempt to explain it. It will be sufficient for our purpose to know that it is extremely sensitive, that a charge of positive electricity moves the index in one direction, and a charge of negative electricity in the other. The motion of the index needle itself is very small, but attached to it is a small mirror. Light from this lime light falls on it, and is reflected on to the screen where you see this spot. The least motion of the needle and mirror of course moves the light-spot along the screen. The amount of motion is noted by means of the scale attached to the screen. Our Leyden jar in this case is made in a form somewhat different to that which we have been considering. The insulator is, as before, a small glass bottle,* but the conductors consist of strong sulphuric acid. Some is put inside the jar, and some in a glass dish in which the jar is set. To charge the jar a platinum wire comes from the electric machine to the acid inside the bottle, while that outside is connected to earth. The jar is charged for two or three minutes and then discharged. I now connect the inner and outer coatings for about a minute by holding the wires from them together between the finger and thumb. The wires are now separated and connected to the quadrants of the electrometer, the earth connection being removed. The spot of light showing the motion of the neeedle at once begins to move along the scale at the rate of about 3 inches per second, showing that the residual charge is coming slowly out. On tapping the

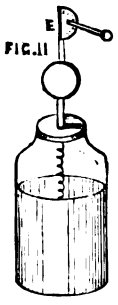

FIG. 11

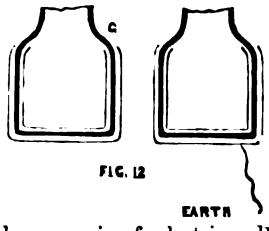

FIG. 12

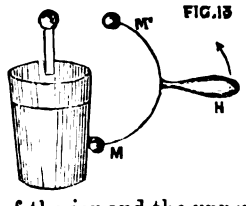

FIG. 13

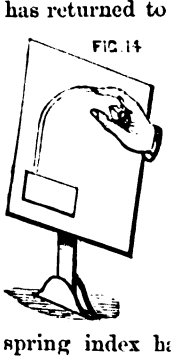
FIG. 14

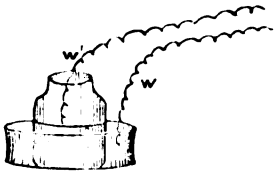

FIG 15

* Delivered at the Royal Institution 1879.

* A bottle about 4 inches high, intended for making a small Leyden jar, was used.

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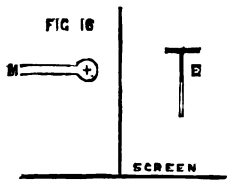
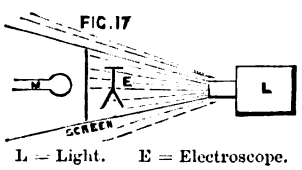
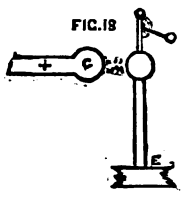
edge of the bottle briskly with a piece of hard wood the pace at which the light-spot moves is at once trebled,* showing that while tapping is going on the residual charge returns much more quickly. If we wish to repeat the experiment, we can discharge the electrometer, and bring the light spot back to zero by holding the wires together for a moment between the finger and thumb. Thus we see that any mechanical vibration communicated to the particles of glass increases their freedom of motion among each other, and, therefore, enables them to recover more quickly when they have been thrown into a state of strain by electric induction. This experiment is nearly conclusive, I think, as to induction being a state of strain. If the charge of a jar were caused by an action at a distance, we should have to state that part of an action at a distance got entangled in the glass and left behind, and that tapping helps it to escape. This hardly sounds probable. This concludes what we have to say about the Leyden jar. We have shown that induction is a state of strain. We will now begin to inquire into the nature of this strain, and try to find out a little about how it is propagated from place to place. Is it propagated simply in straight lines? does the inducing electricity stretch out an arm through the insulator, and pull at the second conductor? or does it act only on the particles of the insulator which are nearest to it, leaving it to them to act on the next set, and so to carry on the strain from particle to particle till it arrives at the second conductor? Faraday asked himself the question, and it occurred to him that there was a very simple method of arriving at an answer. If the induction is propagated from particle to particle of the insulator, it can travel along any direction where there is a continuous chain of insulating particles, whether this chain formed a straight line or not; in other words, it can *turn a corner*. If it were a "direct action at a distance" (whatever that may mean) it could only travel in straight lines. The following experiment is a modification of one designed by Faraday to show that induction can take place in curved lines.

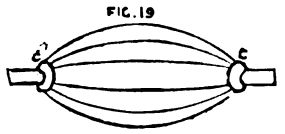


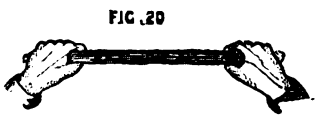
No induction can take place through a metal screen which is connected to earth. The simplest way to prove this will be to try an experiment. Here is a large metal screen connected to earth, and I place the electric machine on one side of it and the gold leaf electroscope on the other. However strongly I work the machine there is no divergence of the leaves. I now take away this screen and put in a smaller one. In order that we may be sure that this, though smaller, is still large enough to cut off all straight lines from any part of the machine to the electroscope, I put the lime light as shown in Fig. 17. You then see that the optical shadow of the electroscope falls entirely on the screen, and the shadow of the screen entirely covers the machine. On working the machine the leaves diverge widely. How did the induction get to them? Our experiment with the large screen shows that it could not have passed through the screen; that with the lime light shows that it could not have come in a *straight* line past the edge of the small screen; and, therefore, we see that it must have come in *curved* lines round the edge of the small screen. This experiment shows a point of difference between the projection through air of light and of electric induction, for while the edge of the optical shadow is almost on the straight line from the source of light through the edge of the screen, the electrical shadow does not extend nearly so far, but the induction curves considerably round the edge of the interposing screen, and extends in every direction in which there is a continuous chain of insulating matter. I think the experiment which we have just tried will prove to you the existence of induction in curved lines. I will now, however, endeavour actually to show you a curved line of induction. If I connect an electroscope to a knob placed near an electric machine and connected to earth, you remember that, when we work the machine so that sparks pass slowly, the electroscope shows a strong induced charge, which increases to a maximum just before each spark and immediately after the spark falls to zero. I will repeat the experiment, as we have not seen it exactly in this form. This experiment shows that induction precedes discharge. All that we know about the subject shows that this is universal law, namely, that there must always be induction along the whole path between the conductors before discharge can take place. It is clear that this law ought to hold, for discharge is only the sudden breaking down of a state of strain, and there can be no breaking down of strain except where strain exists, and induction is strain. The fact of a spark passing along any path shows that induction was previously taking place along that path. It does not, however, show that the whole induction was along that particular path even a very small fraction of a second before the discharge. The induction might have been, and probably was, taking place along many paths. When, however, the insulator broke down at the weakest point, and the spark began to pass, the whole of the induction at once transferred itself to the line of discharge as being the path offering least resistance, and then the breaking down and relief of the strain was completed along that path. Given, then, that induction precedes discharge, if we see curved discharges, we shall know that there was previously curved induction. Let us look at the discharge of a Holtz machine. It consists of a barrel-shaped bundle of sparks (see Fig. 19). Here, in fact, are the curved lines of force, or lines of induction, or lines of strain, produced in visible shape before you. The centre lines are straight, and the strongest induction takes place along them; but induction strong enough to produce discharge takes place in curved lines through all the particles on all sides of the centre line. These lines of force are real, and, I may almost say, tangible things. They can be attracted and shaped by the hand and other conductors. I place my knuckle near the lines, and they bend out towards it. This means that the positively electrified particles of air induce negative electricity on my hand, and then the two electricities attract each other, and displace the whole line of force. It would be difficult to conceive the possibility of attracting an "action at a distance." We have shown that the induction is a state of strain, and we have studied the direction of the strain. We now ask, What is its nature? Faraday showed experimentally that the lines of force attracted each other, so that, if a number of them were side by side forming a "bundle," their mutual attraction drew them together as if the bundle had been tied up more tightly. Maxwell has since pointed out that this is what occurs whenever a rope is mechanically stretched. The pull tending to lengthen the rope is accompanied by a pressure tending to make the rope thinner. To show you this *lateral* pressure, I have here an india-rubber tube. When I stretch it the sides press on whatever is inside it, as you see. Whenever a mechanical tension occurs it is accompanied by a pressure at right angles to it. Maxwell has shown mathematically that an electric induction acting as a tension along the lines of force is always accompanied by an exactly equal pressure at right angles to them. Electric induction, or tension, is a tension of exactly the same kind as the tension of a rope, and the medium which can support a certain induction force before breaking and allowing a spark to pass may be said to have a certain strength in exactly the same sense as a rope may be said to have a certain strength. Sir William Thomson has found that the electric strength of air at ordinary temperature and pressure is 9,600 grams per square foot. Finally, Mr. De la Rue has actually seen in one of his vacuum tubes a star of light showing a rain of particles thrown off at right angles to the main discharge.



L = Light. E = Electroscope.
M = Machine.







* This experiment was plainly seen by a large audience.

ON THE USE OF THE ELECTRIC PEN IN LIBRARIES.*

BY ALFRED J. FROST.

About two or three months since, by the desire of Mr. Garnett, I had the pleasure to introduce the electric pen process to the notice of the principal librarian of the British Museum, and I was subsequently present at some experiments which were made in order to consider the desirability of employing it in the preparation of the "British Museum Catalogue." As these experiments were very satisfactory, it was suggested to me that a short communication on the subject would have sufficient interest to be brought before our association.

Although the system at present in use at the British Museum in the transcription of the catalogue is so well known, I will, in a few words, refer to it, in order that I may the better explain what I consider to be the improvements attainable by the employment of the electric pen.

The system adopted at the British Museum may be briefly described as follows:—After a rough slip has been prepared by the cataloguer, and revised, it is handed to the transcriber, who, by means of the Wedgwood Manifold process, produces four copies simultaneously. These copies are produced on very thin tissue

* Read before the Library Association of the United Kingdom, Feb. 7, 1879.

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paper, and after having been examined to insure correctness ar sent to the binder, who mounts each of them on thick paper. The slips are then trimmed and afterwards inserted in the catalogue.

The electric pen invented by Mr. Edison two or three years ago consists of two small electro-magnets attached to a metallic frame, which is screwed on to the top of a small tube pointed similarly to a pocket pencil; a small wheel is placed horizontally in close proximity to the magnets, upon the axle of which is a crank which works one end of a thin rod, having at the further end an ordinary sewing needle attached which is placed inside the tube. A small battery is used in connection with the instrument.

Upon connection being made with the battery the wheel revolves with great rapidity, and at each revolution the rod with the needle attached is moved slightly up and down. The wheel makes about 2,500 revolutions per minute, and as the cam upon the axle of the wheel is triangular the rod is moved up and down at each revolution three times.

This machine is employed in precisely the same manner as an ordinary pen except that it must be held perpendicularly to the paper, and it will be found that wherever the instrument has passed over the paper a great number of very minute punctures have been made, the characters being thus represented by lines of small holes in the paper.

The stencil, as the written sheet may now be called, is then fixed in a frame made for the purpose, and copies are taken by passing over it two or three times a roller previously saturated with a suitable kind of ink. If the stencil has been written too quickly the writing will not appear in continuous lines, but in a series of closely placed dots; if the proper speed has been obtained the writing will appear as ordinary writing. The ink used is somewhat similar to, but more fluid than, ordinary printing ink, and is absolutely permanent. The copies are easily and quickly made, no more than ordinary care being required in managing the apparatus. It is necessary, however, to take care that the ink is evenly distributed over the roller. It is important to note that the copies may be taken in any quantity up to, I believe, 2,000 upon paper of any desired thickness, or upon card.

It is only right that I should point out objections which may be made to the electric pen, namely, that it is somewhat top-heavy, and at first rather difficult on that account to write with, and that it requires the use of a galvanic battery and connecting wires.

It will be seen from the foregoing remarks that the principal advantages claimed for the electric pen over the Wedgwood process are—

1. That a far larger number of copies can be made.
2. That the tedious and expensive process of mounting each slip is rendered unnecessary; and
3. That the copies can be made on thick paper or card.

Should the British Museum adopt the electric pen or some equally good system for multiplying their catalogue slips it it would be comparatively easy to classify sets of slips into subjects. If this were commenced even from the present time it would prove a great boon to students and librarians and collectors. As the title slips can be mounted on thick paper or on cards, it would be possible for the British Museum to issue copies of their catalogue to the public libraries, who could make use of them as card catalogues, and without mounting.

Collectors know the great difficulty there is in obtaining all that is written on any special subject, even at the time it is published, and how much time is spent in looking over English and foreign journals, and periodicals, and bookseller's and other catalogues.

It would materially help the collector if it were possible for him to know what the British Museum Library contains on the subject he is interested in, and until a subject catalogue is issued, I venture to think that classified catalogue slips of some of the most important subjects would be a great boon, and the list of desiderata would be in the form of a well-prepared catalogue.

I would also point out the advantage which the electric pen offers to Free Public Libraries having several branches. Lists of additions made to the principal library could be immediately communicated to the branches, without the necessity of waiting till such additions could be printed.

Public Societies could, in a like manner, issue to their members accession lists or catalogues at short periods, instead of waiting, as is mostly the case, for twelve months until a printed list is prepared; the slips so forwarded could be arranged from time to time, and kept in the form of a slip catalogue.

Small free libraries, such as those belonging to Mechanics Institutes, &c., could also circulate slip catalogues amongst their members with nearly all the advantages of a printed catalogue, but at much less cost.

Although I have throughout this communication only referred to the electric pen of Edison, I have done so because it is the only means with which I am practically acquainted for reproducing a large number of copies.

LITERATURE.

The Telephone, Electric Light, and other recent Electrical Inventions. By George B. Prescott. New York: D. Appleton and Co. London; E. and F. N. Spon.

We have already noticed the first issue of this work, and have great pleasure in seeing that, not only has it been necessary to issue a new edition, but the increase of information has compelled the author to recast the whole, and make the considerable addition of nearly 200 pages. Altogether the work forms an excellent compilation, containing the history as well as the scientific details of the wonderful electrical discoveries made during the past few years. It is impossible in a short notice to give more than a mere idea of the contents of this book. The author has gathered from various sources, and compressed into some 300 pages, an account of the work done on the telephone and phonograph. He then discusses the Quadruplex System of telegraphy, about which we shall have more to say shortly, illustrating the text with numerous excellent diagrams, enabling the student to realise the value of the apparatus described. A chapter is devoted to "Electric Call Bells," and then the important question of the Electric Light is taken in hand. The inauguration of this light with the century is mentioned, and its progress traced. The narrative in its course includes illustrated descriptions of the various lamps and machines which have at various times been devised. The report of the Franklin Institution is given in full, and this, after all, is the classic report on electric lighting. We shall take another opportunity of calling attention to this chapter, which discusses some of the details of the Edison light. The two chapters following are almost wholly devoted to the consideration of Edisonia, and we cannot help agreeing with the tribute of praise the author metes out to a man who, by his own talent and energy, has made himself a name in every corner of the civilised world. The last chapter deals with some duplex systems, and some of the more recent of the applications of electricity. Altogether it is a work of considerable value, and worthy of a position in the library of every man interested in electrical pursuits.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

Report of the Directors to be submitted to the shareholders at the fifteenth ordinary meeting to be held on Tuesday, the 4th day of March, 1879, at one o'clock precisely:—The Directors have the pleasure to submit their fifteenth annual report to the shareholders. The accounts for the year show a net profit of £87,746 after charging the interest on the debentures. To this sum must be added £61.247 3s. 6d. brought forward from last year, making a total of £148,993 3s. 6d. From this amount is deducted the interim dividend of 5 per cent., paid 10th July, 1878, amounting to £22,410 leaving £126.583 3s. 6d. to be dealt with. Of this sum the Directors propose to distribute a dividend of 15 per cent., or £67.230, being at the rate of £1 16s. per share, and making, with the amount already paid, a total dividend for the year of £2 8s. per share in cash, free of income tax, leaving £59.353 3s. 6d. to be carried forward to the next account. The principal operations carried out by the Company during the year 1878 were as follows:—The laying of two sections of the Western and Brazilian Telegraph Company's cables on the coasts of Para and Maranham in the Brazils, amounting to 565 nautical miles, in accordance with the terms of a contract entered into with that Company. An endeavour to repair the Anglo-American Telegraph Company's cable of 1866, which proved unsuccessful, the decayed condition of portions of the outer covering rendering it impossible to raise the cable, except in short lengths. Two of the Company's ships were employed on this operation between the 25th of May and the 27th of July. The manufacture and laying of a cable for the Eastern Telegraph Company between the Island of Cyprus and Alexandria, and the manufacture of certain lengths of cable to enable that company to duplicate and connect up portions of their system with the islands of the Levant and Constantinople. The manufacture of 289 miles of cable for Her Majesty's Government.—The total quantity of cable manufactured during the year was 2.631 miles. The North Woolwich Works, lately the property of W. T. Henley and Co. (Limited), and on which this Company held the first mortgage, have been legally transferred to, and are now in the possession of, the Company. The shares of the Black Sea Telegraph Company have been transferred to the Eastern Telegraph Company, and the cable from Odessa to Constantinople now forms part of its system. The factories at Wharf-road and East Greenwich are in thorough working order. To replace the steamship Hibernia, the steamship Scotia has been purchased, and she, together with the Calabria, is undergoing extensive alterations and improvements, which, when completed, will place the Company in possession of four large and efficient vessels equal to the performance of any cable-laying operations that may offer. The retiring Directors are Sir George Elliot, Bart., and Mr. Philip Rawson, who, being eligible, offer themselves for re-election. It will be necessary for the meeting to appoint auditors for the ensuing year. Mr. John Ball and Mr. Gane, who retire, offer themselves for re-election.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN ci faranno cosa gradita accettando il cambio che loro offriamo.

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THE USE OF ELECTRICITY IN THE HOUSE.

A mere enumeration of the many electric apparatus devised for household purposes would hardly show how rapid and how extended the various adaptations have been in this direction. The political economist states, as one of his fundamental axioms, that the value of an article commercially depends, to a considerable extent, upon the demand for it. Of course, this is only one factor in determining value, but it is an important one. The noticing, then, of the extended use of electrical appliances may not be without its interest to the large number of capitalists who are looking for a fair field of investment. Students of this and similar sciences are of two kinds—those who endeavour to determine the laws which regulate and control the observed phenomena, and those who attempt to apply these laws in the amelioration of the condition of mankind. The latter, if successful, generally obtain immediate reward and recognition, the former frequently die before their claims are acknowledged, and, in fact, a future generation has often to decide as to the claims of priority of discovery, and mete out a slow vote of thanks for the valuable labour performed.

The greater the number of applications any science gives to us, the greater the benefit obtained. The field open for the applications of electrical apparatus is so vast, and so little explored that it seems a most promising direction for investigation. Let us briefly glance at what has been done. The telegraph stands out prominently, and occupies the first place in our retrospect. It has become invaluable, although it may be termed a thing of yesterday. So many are its uses that it has forced its way in every direction. The merchant directs his factory in the next street, or a hundred miles away, from the table of his counting house; the squire orders his horse or his carriage without moving from his library. In such cases as the latter, however, the telephone is taking the place of the telegraph instrument, so that the voice of the owner gives the command. The electric bell has long been recognised as in every way better adapted for its work than its crank and lever rival. One suggestion might be made here, that instead of making the button which completes the circuit when pushed, a fixture, it should by means of a cord enclosing the necessary wire be moveable, and thus capable of being placed in any convenient position. We know this is frequently done, but it would conduce to greater comfort if the number of cases were still largely increased. In the bedroom it should be the rule with no exception.

The electric light is yet in embryo, and cannot be applied to ordinary rooms. We do not doubt its ultimate success, though time enters largely as a factor in such development. We are not so sanguine as some of our savans that the laws of electricity have been so well studied that little remains to be done in this direction. The investigator frequently encounters phenomena which he finds it difficult to explain by means of existing hypotheses; still the science gives us laws which, for all practical purposes, are accurate, and which may, without fear of making mistakes, be used to determine the value of almost any application that can be suggested. When some means have been devised to utilise the waste heat from our fireplaces, then we may, perhaps, hope for an extension of the electric light into the drawing room.

In America there has of late been an adaptation of electricity to a remarkable extent as a fire or burglar indicator, and it is a marvel to us that this application has not spread to a greater extent in our own populous business centres. In London, to a comparatively small extent, such a system has been carried out by the Exchange Telegraph Company, but the general opinion seems to tend to procrastination till the evil day comes. The first moments of a fire are the most important; then, and only then, immediate action will prevent great loss; whilst, however, men and engines are being sought, the fire gets too good a hold to be easily extinguished. An automatic system, at a trifling cost, would indicate the position of the outbreak, and the remedy would be practically instantaneous, and thus the evil effects would be obviated.

Our cousins, again, set us a good example by using small electric-motors for many purposes as yet undreamt of here. The grocer uses one to cut his sugar, to grind his coffee, to shake his plums, the barber to turn his hair brushing machine, whilst the housewife hastens to save manual

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labour, and apply the electric current to her washing and mangling, and sewing machines. Several small motors, said to be economical, are to be obtained in the States. We, as yet, have not heard of any importation, even for experimental purposes, into England.

Let our practical men bear in mind that telegraphic apparatus, the telephone, and electric bells are fast becoming necessaries of life, that electric motors, electric pens, electric writing apparatus are knocking at the doors of the multitude, seeking admission, that lightning protectors are the exception and not the rule, that in fact electrical science is being applied more and more to meet the wants of every day life, so that it behoves us and all who are interested in the subject to aid the development that seems so amply foreshadowed.

CORRESPONDENCE.

"POTENTIAL" VERSUS "TENSION."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I must leave your readers to judge whether Dr. Lodge has fairly met the question which has been raised in regard to the employment of the term "potential" instead of "tension," and whether he has attached due consideration to the fact, mentioned in my last communication, that the accepted definition of electromotive force was formerly "difference of tensions," for which expression "difference of potentials" has comparatively recently been substituted by certain writers. It seems to me something like a *mauvaise plaisanterie* on the part of Dr. Lodge to tell those who, years before he was ever heard of in connection with electricity, used the former term, in speaking, writing and teaching, precisely in the same general sense which is now attached to the latter, that "they might just as well object to the use of any name for the physical quantity we speak of as temperature" as to object to what appears to them—and what has repeatedly been admitted to be—a simple substitution of one term for another. A better parallel would have been established if Dr. Lodge had said "they might just as well object to the substitution of the term 'conditional' for 'temperature.'" For, although Dr. Lodge informs us that "the word tension is *wanted* for another and entirely different thing," I maintain that there are not *two* properties of electricity which have been respectively designated as "tension" and as "potential;" but that *one* property only, that which produces the electrometric indication, was formerly characterised as "tension," and is now, generally, referred to when *either* term is used. Of course, there is no objection to the use of any number of terms, fanciful or otherwise, in those purely mathematical exercitations which delight certain theorists; but in practical electrical science, where simplicity and accuracy should go hand in hand, the use of two terms to signify what is essentially the same thing is obviously objectionable.

In regard to Dr. Lodge's statement that the term "potential" "has *established* usage on its side," it seems necessary that I should point out to him that the present question has been mooted in consequence of the refusal of your contemporary, *l'Electricité*, representing the great majority of our *confrères d'outre Manche*, to recognise or tolerate the use of this term in lieu of "tension." Will Dr. Lodge allow me, in addition, to refer him to the extract from the *Panthéon de l'Electricité* which appears in your notes of Feb. 1 (p. 121).

The statement that there is no tension inside a hollow charged conductor is merely an antiquated mode of saying that the dielectric inside such conductor does not ordinarily form part of the inductive circuit. This statement, in fact, belongs to the electrical "science" of the old text-books, and of some modern centres of learning where it is well understood that a galvanometer must be inserted in a *conductive* circuit, but where it is *not* understood that an electrometer must equally be inserted in an *inductive* circuit, before an effect can be produced upon the instruments. Of course we cannot speak of the tension of the *charge* inside such a conductor when no such charge exists; but what is termed the tension at any point of the interior surface is the tendency of the external charge to pass in a circuit, inductive or conductive, established through this point. Thus the tension at any point of the interior surface is the same as that at any point of the exterior surface; and, generally, the tension is necessarily the same at every point of a conductor or system of conductors not traversed by a current.

I am glad that Dr. Lodge agrees with me in condemning the term "tension of current," but, nevertheless, I cannot agree with him in calling the expression "density of current" a "meaningless abomination." The same current may pass through an electrolyte between electrodes of one square inch or of one hundred square inches surface, and the electrolytic effects may vary very much in the two cases. In electro-metallurgy, "if the density of current be too great, we get a sandy or even black powder as a deposit; if it is too slight, we get a crystalline brittle deposit." For further information on this point, I beg to refer Dr. Lodge to Mr. Sprague's "Electricity," p. 283. No doubt he would not have used such strong language had he been aware of the absolute necessity for, and the philosophical accuracy of, the term in question.

I am not aware how unit positive electricity can be placed at a *point*, and I have no idea what the potential would be if the feat could be accomplished; but the tension (or potential) of a point or surface is *twice* the potential energy stored up in unit quantity of electricity when accumulated under the same tension.—Yours, &c.,

DESMOND G. FITZGERALD.

EDISON'S DYNAMO-ELECTRIC MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Being but an amateur, it is with fear and trembling that I venture to criticise the professional criticism of the *Engineer* upon Mr Edison's electric machines.

But having a very sincere admiration for the genius of its inventor, it has occurred to me that the adverse judgment passed upon his work by the said critic, as it appeared in your last issue, should not go altogether unchallenged.

He commences his strictures by doubting if such a machine was ever constructed at all, although Mr Edison in his specification distinctly states that he "uses this machine especially with his electric light." Now that is rude; and a person of such eminence as the *Engineer* critic could afford, I should think, to be courteous to so insignificant an individual as Mr. Edison.

He then gives three reasons for condemning the invention. I need only say of the first that he endeavours to justify it by establishing a "strict analogy" between an oscillating pendulum, with an attractive magnetic influence just below it, and a vibrating reed with a similar attraction on one side of it; and he is ready to brand Mr Edison as "ignorant of mechanical truths" and destitute of "scientific training" if he does not see it.

Poor Mr. Edison! I do not think he will perceive the "strict analogy," and then, doubtless, he will feel ill all over when he reads what an ignoramus he is.

His second reason is—well, we will say—peculiar. He insists upon the inventor having some stops in the machine—says, in fact, that he can't do without them—for the vibrating prongs to hammer against, and then objects to the effect which they would produce. Now, Mr. Edison, poor man, does not want these stops, and has not got them, and would have no earthly use for them, since the distances between armatures and magnets are regulated by the mechanism that maintains the vibrations, whether revolving cranks, or the direct strokes of small engines, or any other suitable arrangement.

His third and last reason for pronouncing the invention a failure, is quite amusing. He asks, "Does Mr. Edison really imagine that he can make a tuning fork, two metres long, vibrate over sixteen times in a second?"

I should advise Mr. Critic to make a few experiments with vibrating rods of various lengths and thicknesses before passing judgment upon such a man as Mr. Edison again. Let him try to obtain a musical note by such vibrations, bearing in mind that at least sixteen vibrations per second are required to produce the deepest bass note appreciable as tone by the human ear. Then let him study some elementary work upon mechanics, so as to convince himself of the possibility of producing a motion of sixteen strokes a second, through a space of an inch or so, to assist the fork in keeping up its vibrations. And then he will, perhaps, come to the conclusion that Mr. Edison really does imagine that he can do what he says he has done.—Yours, &c.,

Castle-road, Southsea, Feb. 24. AMATEUR.

(Translation.)

AUTOMATIC CURRENT REGULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been drawn to a letter, in No. 13 of your excellent journal, from Mr. William Gifford, in which is described an automatic current-regulator, devised last October by the writer of the letter in question.

I take the liberty of addressing to you these few lines, to

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assure you that there is no point of resemblance between Mr. Gifford's apparatus and mine; and I enclose a photograph of the latter, which will remove all doubt of the matter.

The variable resistance which I introduce in the circuit to regulate the current is neither pulverised carbon, as in Mr. Edison's case, nor rabbit hair coated with plumbago, as in the case of Mr. Gifford, but simply a wire, the known electrical resistance of which allows us to calculate *exactly* the resistances which come into play in the apparatus.

I shall be glad to supply you with any information you may require relative to this instrument, which you are at liberty to publish should you consider it of interest to your readers.—Yours, &c., E. HOSPITALIER.

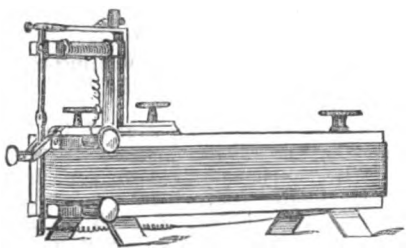
24, rue Freycinet, Paris.

(Enclosure.)

ON AN AUTOMATIC CURRENT REGULATOR.

BY M. HOSPITALIER.

"The apparatus which we have the honour to present to the Academy is composed of a resistance coil wound in a single layer, the wire of which is denuded over a breadth of one centimetre on a line at right angles to the direction of the wire. A slightly convex lever, forming a *distributor*, is in contact with the wire at this spot. This distributor is connected by one of its extremities with an electro-magnet, through which circulates the current which it is required to regulate. This lever is held at its other extremity by a 'retaining spring.' The circuit is formed of the resistance coil, the lever, and the electro-magnet. The apparatus being regulated for a given intensity, a certain number of turns of wire are introduced into the circuit by the distributor. Should the current augment, the armature of the electro-magnet is more strongly attracted, the distributor shifts its point of contact and introduces into the circuit a greater number of turns of wire, the resistance is augmented, and the current is diminished. The inverse effect is produced should the current diminish.



The current arrives at the lower binding-screw (shown to the left), traverses the turns of wire on the coil, the lever and the electro-magnet, leaving the apparatus by the upper binding-screw.

"By properly regulating the retaining spring, the electro-magnet, the wire, and the curve of the distributor, the system may be made astatic; the apparatus then allows of a current which is mathematically constant.

"In practice, the current may be maintained within two limits fixed beforehand, and as close as may be desirable.

"From the point of view of industrial applications, the apparatus may be applied in galvanoplastics for preventing the fusion of platinum or iridium wires raised to incandescence; and, should the problem at any time receive a practical solution, to the distribution of electricity in private houses, where the apparatus will play the part of a true meter and divider of the electric current."

ELECTRIC LIGHTING.

(CONTINUED FROM P. 130.)

Report presented by M. Cernesson, in the name of the Third Commission of the Municipal Council of Paris:

M. Cernesson places upon record that, at the Avenue de l'Opera, from May 30 to Oct. 10, 1878, there were 66 cases of temporary partial extinction of the electric light, lasting from 1, 2, 3, 5, or 10 minutes up to 15, 30, 35, and even 40 minutes. Generally the extinction was confined to 4 of the lamps; on some occasions it extended to 14 or 16 of them. The total number of lamps or *bougies* was 62.

II. *Comparison of illuminating power, or of the relative intensities of light.*—"The light produced by a Carcel lamp, burning 42 grams, (648 grains) of refined oil per hour, is generally taken as the unit of illuminating power. In comparing with this standard an ordinary street gas jet, termed bec de ville, burning 140 litres (4.94 cubic feet) per hour, it is found that the light so produced equals 1 1-10 that of a Carcel unit. The light produced by a Jablochkoff candle has been almost exactly determined by M. Th. Lévy, and also by the determinations made at the Avenue de Villiers' works belonging to the Compagnie d'Electricité, by M. F. Leblanc, inspector of gaslighting for the city of Paris. From these various investigations it has been found that at these works an electric light furnishes about 30 Carcel units. But as such a light cannot be used naked, but must be protected by an opal or other glass, the lighting power will be reduced to 18 or 20 Carcels measured on the plane of the light, and to 12 1-10 Carcels measured on the oblique rays falling on the ground. As will be seen, there is a considerable quantity of light lost in the passage of the luminous rays through the opaque glass. This quantity of lost light should be reduced as far as possible. The representatives of the Compagnie Générale d'Electricité state that their utmost endeavours were directed to this object, and they trusted to succeed in it. From the foregoing it results that one electric light gives on the ground a power equal to 12.10 Carcels, whilst a street gas jet gives 1.1, so that the former is eleven times more powerful than the latter. But the gas company, on the other hand, state that by increasing the size of the jet, and thereby its consumption of gas, the lighting power of the latter can be largely increased. Thus a jet burning 200 litres (7ft.) per hour furnishes a light equal to 1.72 Carcels. In this case, therefore, the electric candle would be equal only to seven jets of the improved type. The gas company state also that they are prepared to carry out any experiments in improved lighting that the city of Paris may desire, either by increasing the consumption of the burners, or by modifying the arrangement of the lamps."

After insisting upon the necessity of more accurate means of measuring the quantity of gas consumed, M. Cernesson continues as follows:—

"Having collected and examined all the necessary data on the questions above referred to, the committee addressed themselves to the consideration of the principal question whether the city of Paris should agree to grant the concession for three years sought by the Compagnie Générale d'Electricité in the terms contained in the following letter:—

"'To the Engineer-in-Chief (Ville de Paris).

'Paris, November 19, 1878.

'I beg to submit to you the documents relating to the proposition already made relative to the lighting of various parts of Paris by electricity. The Compagnie Générale, which I represent, would undertake to establish, at its own cost, and in the various places mentioned in the scheme submitted (Place and Avenue de l'Opera, Place du Théâtre Français, Place and Boulevard de la Madelaine, Boulevards des Capucines and Italiens, Rue Vivienne, Place de la Bourse, Rue du Quartre Septembre, Rue de la Paix et Place Vendôme), 171 lamps, distributed according to the views of the engineers of the various sections, subject to the following conditions:—Wherever it is possible, without interrupting the gas service, especially on the refuges at crossing places, the *matériel* of the city would be employed, and would serve to carry the electrical apparatus; in places where additional lamps are required, they would be furnished by the society, of a pattern submitted to the Administration and accepted by them. The charge of lighting, commencing at the usual hour, that is to say at dusk, and finishing at 12:30 midnight, would be 60 centimes per lamp per hour. The term of the contract would be for three years, dating from the time of installation. The Municipal Administration would furnish gratuitously to the company the locations required for the installation of the engines and electric machines. Generally speaking, these locations would be, amongst other places, a site on the ground level, Boulevard Malesherbes, near the Madelaine (in a kiosk), and in the basement of the Bourse. The society would be authorised to execute in the public streets all the works necessary for laying the wires and establishing the system, conformably with the municipal regulations. It would have, moreover, along the route so lighted the authority to take from the current formed by the conductors, branches to feed any private establishment desiring to use the light. In such a case, in order not to affect the interests of the Municipal Administration, the company would pay per lamp thus led off a sum equivalent to the cost of an equal light in gas jets. The company would engage, moreover, to undertake at its own cost the relighting of the gas in the event of the electric lights being extinguished, whenever it may be found necessary.'

"The results of the foregoing proposition, if carried into practice, would be as follows: The number of lamps would be 171, and the cost of lighting would be per hour $171 \times 60 = 102.60$ (£4.10), or for a year, reckoning 2,073 hours, we should have

	francs	£
$102{,}60 \times 2073 =$	212,689.80	(8,507.6)
Lighting by gas as at present costs	34,347.54	(1,373.9)
So that the annual loss by the electric lighting would be	178,342.26	(7,133.7)

An examination into the causes of this extra expense forms the points of departure for the following conclusions:—

If, on the one hand, the city of Paris is desirous of encouraging any attempt, or any new invention, referring to public lighting, in the hope, however chimerical, of arriving one day at a more

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perfect and at the same time a more economical system, it should not, on the other hand, to its own cost, extend unreasonably such attempts, and especially in such a manner as to pay for lighting on terms which would be really an actual subvention to new lighting companies. As regards the Compagnie Générale d'Electricité, it has already, and from its commencement, received a powerful support from the Municipal Council, since that body has, during six months, made payments amounting to more than 60,000f. (£2,400.) This assistance has enabled the company to show to the whole world their method of lighting, and they have thus derived a large benefit, both from the moral and pecuniary support of the Ville de Paris.

"Under these conditions, is it expedient to accept the proposals of the company in their entirety? The committee thinks not; it considers that electric lighting is still in a state of experiment, and that it requires numerous improvements, especially as regards regularity of working. The frequency and duration of the interruptions to the light, and its increased cost, necessitate the simultaneous maintenance of appliances for gas illumination, involve complication, and consequently an excess of cost. For these reasons the committee almost unanimously recommend that the proposition made should be declined, both as regards the bases suggested and the terms demanded. But, at the same time, bearing in mind the advantage which would accrue to the city if it furnished the means to insure the complete success of this new mode of illumination, and the favour which this system has received in Paris from the public, the committee believes that it is justified in recommending a continuation of the system experimentally and for one year from the 15th inst., under conditions which may eventually be decided upon.

"On other hand, it will have been gathered from what has been already stated that the Paris Gas Company appears desirous of entering into competition with the Compagnie Générale d'Electricité, and to improve the present system of lighting. The position of the gas company is somewhat delicate; an improvement in gas lighting involving a greatly increased consumption signifies a corresponding expense for the city, and a resulting net profit to the company. It will be, therefore, understood that, however they may desire it, the representatives of the company cannot propose this alteration. They prefer to say nothing, but to continue carrying out the contract made with the Ville de Paris. The present arrangement is this: The city furnishes the number of lamps, &c., required, and the company supplies the gas burnt. Thus the position of the company is a passive one, and it is not called upon to enter into questions relating to improvements in the mode of lighting. Nevertheless, since its interests are greatly involved in the use, by the Ville de Paris and by the public, of the commodity it manufactures, it desires to compete in trials tending to obtain the greatest possible advantage from gas. The representatives of the gas company state that they have already made many exhaustive experiments in this direction, and that they are ready to continue them even at their own cost.

"As the representatives of the gas company believe there is every reason to hope that they can give, at a lower cost, a light equal to that furnished by the Jablochkoff system, the committee think it advisable to compare fully the two methods under exactly similar conditions. Thus for street lighting, the Avenue de l'Opera, illuminated by the Jablochkoff candles, may be compared with the Rue du Quatre Septembre lighted by improved gas appliances. For public spaces a comparison could be instituted between the Place du Château d'Eau and the Place de la Bastille. Following the same idea in reference to public buildings, the committee recommend the Halles Centrales, two similar pavilions of which could be lighted by the same methods. Some members of the committee would desire to extend the scope of these comparative trials to light by electricity the façade of the Chamber of Deputies, and by the improved gas the front of the Madelaine, but the majority declined to entertain this view, and have even recommended that the illumination of the former building should be discontinued.

"The committee thus recommend that the comparative trials shall be carried out as follows:—

Jablochkoff System.—1. Place and Avenue de l'Opera and Place du Théâtre Français. 2. Place de la Bastille. 3. One of the pavilions of the Halles Centrales.

Improved Gas.—1. Rue du Quatre Septembre. 2. Place du Château d'Eau. 3. One of the pavilions of the Halles Centrales.

(TO BE CONTINUED.)

THE COST OF THE ELECTRIC LIGHT.

We are gradually accumulating authentic information relative to the cost of the electric light under present conditions, and in almost every case the result states that electricity as yet cannot compete with gas. It is necessary to state the facts plainly and clearly; but, at the same time, we may say that the results obtained were fully expected, and, in our view, in no way tend to prevent the great future of the electric light. The great mistake that has been made will probably bring users of light to turn for information from charlatanism to those who have really studied the subject. It is impossible, with the systems at present in use, to obtain a fourteen or twenty-candle light by electricity for the same cost as a gas jet of equal illuminating power. But even with the present system, when it is required to obtain a light from five to ten thousand candle power electricity is far preferable to gas. The future will see, and we hardly hesitate to say the early future will see, great improvements made in electric machines, and in the carbons or other burning substances, so that the electric light will be produced at a much less cost than it is at present. The following data have been carefully obtained by a competent engineer in a large engineering works in the north. The department in which the electric lights are used is 170ft. long by 45ft. broad; down each side are lathes and other machines, the centre of the space being devoted to fitting up crossheads, pumps, piston rods, &c. The number of gaslights on the columns for giving the general lighting is twenty-two, two burners to each reflector. Each machine has its usual portable gaslight. The men at work in the centre generally use candles. On deciding to use the electric light, two Gramme machines were purchased, each machine being of 6,000-candle power, also two Serrin lamps, the whole electricity-producing gear being as follows, and costing the amounts against each item:—

	£	s.	d.
Two Gramme machines, 6,000-candle power each, at £100 each	200	0	0
Two Serrin lamps, at £18 each	36	0	0
100 metres of cable, at 2s. 9d. per metre	13	15	0
40 metres of carbons, at 2s. 6d. per metre	5	0	0
Net cost	254	15	0

A two-cylinder engine was fitted up expressly to drive the two machines; the diameter of the cylinders 5½in. by 10in. stroke; mean pressure was, at least, 30lb.; and the revolutions were to be 200. At this piston-speed it was estimated that fully 8 indicated horse-power could be had. On setting the electric machines on it was found they could not be got up to the speed necessary to produce a full light. It was seen that there was not power enough; besides, by the two machines being driven off the one engine, the light obtained at each lamp was very fluctuating, this arising, in a measure, from either lamp carbons sometimes splitting off, and, as a consequence, the engine ran faster, driving the other machine at an increased rate and increasing its brilliancy. On ignition taking place again the engine speed fell. Alternations such as these, together with a limited brilliancy of light, led to the determination to drive one machine with the engine solely, and the other off one of the works' engines.* This was done, and now the lights in each lamp are working steadily and satisfactorily. From the experience acquired it is concluded that it requires at least 1-horse power for every 1,000-candle power; also, that each machine should be driven independently, the whole of the necessary driving gear being and costing as follows:—

	£	s.	d
Engine for driving one 6,000-candle power Gramme machine, cylinders 5½in. by 10in. stroke	40	0	0
Piping	1	10	0
Countershaft, pulleys, and belts	6	15	0
Labour fitting up wires, lamps, and machines	2	10	0
	50	15	0
Two machines	101	10	0
Cost of machines, lamps, cables, and carbons	254	15	0
Total net cost	356	5	0

In order to arrive at the comparative cost of the electric *v.* gas-light, the data available are as follows, taking the cost of the electric light, per diem of four hours—two in the afternoon and two in the morning—this being the actual time it is in use:—

	s.	d.
In four hours both lamps burn ½ metre of carbons, which, at 2s. 6d. per metre, is	1	3
Coals consumed by engines in four hours, at 3½lb. per indicated horse-power, 2 cwt.	1	0
Oil consumed by engines and shaft in four hours	0	2
	2	5

Or equal to 7½d. per hour. The actual gaslights dispensed with are twenty-two on columns and eight to ten on machines—say

* NOTE.—On driving the Gramme machine from shop engine, the revolutions of the engine fell 14.

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eight—giving a total of thirty burners. Each burner uses, say, in four hours 13 cubic feet of gas, or 390ft. in all, which costs 11¾d., or nearly 3d. per hour. The quantity of gas consumed in the department is ascertained from our total daily amount used as per gas meter, and is pretty accurate in the rate used per burner during four hours. Notwithstanding the use of the electric light, the author of the report is compelled to admit that the workmen in the centre of the shop, and during some operations of machine work, have still to use gas and candles. Nor is it easy to see how it can be otherwise in an engine factory, the shadows where the electric light is on being so deep. In actual practice for a factory its cost is 100 per cent. over the gas at least; because the wear and tear of the electric machine must be taken into account, also the necessary attention given to the lamps and machines. Its light has a very pleasing effect throughout, partaking of the nature of a tropical moonlight. The men like it, as it enables them to see around their jobs better. Still, with all these advantages, it will have to be produced more cheaply to satisfy this age or the next, and then gas will still be required for engine building, turning, and fitting, unless a handy, portable, cheaply-made workman's electric lamp is invented; then will gas go out and be relegated to the limbo of things that did their duty and died from progression. The Gramme and Siemens machines are too dear. There is really not the weight of material in them, nor labour on them, to warrant their present market price. This fact tends greatly to prevent a more extended use of the electric light, as it increases the first cost so much.

A CAPE CABLE.

On Friday, the 21st February, 1879, a deputation waited upon Sir Michael Hicks-Beach, Bart., M.P., Her Majesty's Principal Secretary of State for the Colonies (with whom was Lord Cadogan) at the Colonial Office, Whitehall, to urge upon Her Majesty's Government the expediency of laying down a telegraphic cable at once to the Cape of Good Hope.

The deputation consisted of Mr. Henry Edwards, M.P.; Mr. Giles, M.P.; Mr. Otway, M.P.; Mr. C. Forester, M.P.; Mr. Massey, M.P.; Mr. Goldney, M.P.; Mr. John Holms, M.P.: Mr. M'C. Torrens, M.P.; Sir Tollemache Sinclair, M.P.; Mr. Hick, M.P.; Mr. Palmer, M.P.; Colonel Bourne, M.P.; Mr. Dodds, M.P.; Sir J. C. Dalrymple-Hay, M.P.; Lord Colin Campbell, M.P.; Sir Thomas Bazley, M.P.; Sir Sydney H. Waterlow, Bart., M.P.; Mr. W. H. James, M.P.; Colonel W. Mure, M.P.; Mr. James Yeaman, M.P.; Lord Charles Bruce, M.P.; Mr. Burt, M.P.; Mr. Pulestone, M.P.: Mr. Pender, M.P.; Sir George Campbell, M.P.; Mr. Errington, M.P.; Sir Baldwin Leighton, M.P.; Sir Henry Havelock, M.P.; Mr. Peter M'Lagan, M.P.; Mr. J. C. Clarke, M.P.; Mr. George Anderson, M.P.; Captain Milne-Holme, Mr. W. G. Soper, Mr. Nicholas Ennis, Mr. Blaine, Mr. John Noble, and Sir James Anderson.

Colonel MURE, M.P.: Sir Michael Hicks-Beach, I have the honour to introduce to you a deputation of gentlemen, mainly, I think, composed of members of the House of Commons. I feel that, in undertaking this duty, I have undertaken what I am scarcely able to do justice to, but our object in approaching you to-day has sprung from circumstances which have recently occurred in South Africa. The object of our appearing before you to-day is, to impress upon the Government the extreme importance of establishing, at an early date, telegraphic communication with the Cape of Good Hope. We all know perfectly well, and nobody knows better than yourself, that that communication cannot be established by private enterprise, simply from the fact that in itself it would not pay. Before I was in Parliament the matter was brought before the House by Lord William Hay, and since then many deputations have approached you on the subject; and it will be within your recollection that a deputation came to you from various commercial interests, when representatives from the West Coast of Africa and the East Coast of Africa, and others having an interest in the colony, were represented in this room. I wish to call your attention to the interest which the public mind attaches to this subject, and has done for two years past; and, when the war broke out in Africa, you received a memorial from a number of gentlemen, who urged upon you the importance of this matter, without regard, in one sense or another, to any particular commercial interest, although the deputation was confined to persons interested both in the West and the East Coast trade of Africa. Well, it is a matter of surprise to any one who looks at the map of the world to see how isolated Great Britain is from this great dependency of South Africa, while Russia has the most perfect communications over the whole of her enormous possessions, extending from the Archangel to Japan, from Japan to New Zealand, and from New Zealand you find it going back to Aden, and from Aden to Lisbon, and from Lisbon to Chili, and from Chili to the West Coast of America. And yet here we have the greatest commercial nation in the world up to this time without telegraphic communication with one of her dominions, in which we have great interest. But now we know we have unparalleled disasters and dangers. Here we have had these great telegraphic systems carried on by British capital and enterprise, and yet Great Britain has not thought fit to devote, or has not been able to devote, one shilling of capital to connect herself with this great dependency. As to the interests now involved, I think you will agree with me that they are almost paramount. In the first place, I do not suppose that any gentleman who has gone through recent Blue Books, without expressing any opinion whether the faults have laid in Africa or in this country, or expressing any opinion whatever on party grounds, yet he must be certain that the Government at home and the Government of South Africa had been placed in a position of great difficulty, and the dangers have been increased by the want of immediate communication, which, had it existed, might have mitigated in some degree, the great disaster which we all now more or less mourn [hear, hear]. That is what we may call the political danger, but it embraces a military danger also, and I will point out that, in a colony situated as South Africa is, and having regard to her conditions, which change from day to day—and I may say that I have had some experience of what a native war is upon the borders of a colony, and I know that the dangers not thought of to-day in a few days afterwards become a peril—and I fearlessly assert that the present forces have not been anything like sufficient for the purposes of the colony. And if you will remember what the feelings of those colonists out there must be, the sense of want of security, and remember how much suffering, terror, and suspense is now being endured within the homes of many at this moment, which might not have been the case had there been a telegraphic communication, by means of which their hopes would probably have been realised and their suspense relieved, irrespective of its value to us from a commercial point of view. Let me say a word about the feeling at home on the subject. You will remember there were lists of names given the other day in the public journals of the killed and wounded, and descriptions of how our troops were killed and tortured by the Zulus, and what an inestimable relief it would have been to friends and relations at home could they have known the real fate which had befallen those abroad. Well, I understand that these words which I have used now are merely commonplaces, for all the thoughts I have uttered must have been felt over and over again since the disaster occurred. One thing I will urge upon you, and it is this. We understand there is, at this moment, ready to hand, of nearly 1,400 miles in length, a duplicate cable, which is at present intended for Australia, and is, I may say, lying in wait to become the means of relieving much of the suffering and anxiety which is at this moment going on; and, without expressing an opinion as to what amount of money ought to be spent, or how far the Government will be justified in spending money on such a thing, I, for my part, express this desire, that there may be no time lost if that cable can be obtained, and that, if no other can be obtained on equally good terms, or at equally short notice, that that cable be taken and laid down [hear, hear]. I hope the words I have uttered will have expressed what we desire, and that we may get what we wish [hear, hear].

Sir THOMAS BAZLEY, M.P.: From a deep sense of public duty I join my friend this afternoon in waiting upon you to make this remark. I agree with my friend, Colonel Mure, that, both politically and commercially, telegraphic communication with the Cape would be of the last importance. Commercially, I know there is great anxiety felt at the present time with respect to the safety of property out there, and with respect to the industrial classes who have emigrated from this country to the Cape there is also great anxiety felt, for fear there may be some disaster which may involve their relatives in serious injury. That, I hope, will not prove to be the case; but I would take the liberty of submitting for your consideration that, if this very excellent means of communication were established in the south as well as it is in the north of Africa, that possibly that great calamity might have been averted which has taken place in Zululand. I am sure the matter will receive the gravest consideration at your hands, and as my friend Colonel Mure has thoroughly exhausted the topic, I will not further trespass upon your time [hear, hear].

Mr. A. GILES, M.P.: I will venture to remind you that twenty-two years ago I commenced my connection with the Steamship Company which now carries the mails to and from the Cape. Twenty-two years ago, when the steamship service commenced, the communication was sufficiently supplied by one steamer a month, with about 600 tons; whereas the importance of the service has so much increased that it requires six steamers a month, of 3,000 tons each, to supply it; and that fact, I think, should be sufficient to justify the Government adopting the course now required of them. It is quite certain that, although the colonies of Natal and Cape Town are capable of paying their postal service, they are not rich enough to subsidise a line to the Cape. They have offered to give a liberal subsidy for a cable—I believe that the Cape Colony has offered £15,000 and Natal £5,000 a year towards it—but it is certain that that would not be sufficient, because, commercially, the cable itself would not pay. There is already telegraphic communication to Aden, and, if time was an object in establishing this communication, the readiest means of doing it would be, in the first place, to get a cable laid from Aden to Zanzibar, a distance, I believe, of 1,700 miles; then from Zanzibar it would be necessary to continue it to Mozambique, which is about 500 miles further; and from Mozambique to Delagoa Bay it is about 800 miles; and then from Delagoa Bay to Natal it is a further distance of 230 miles. Now, it is clear that these operations might be going on simultaneously. I think if there is a cable ready to be laid of 1,400 miles in length, that it would not take much additional time to lay the additional length between Natal and Zanzibar. I thought that my putting you in possession of these facts might help you in the solution of the matter.

Mr. YEAMAN, M.P.: I cannot understand why this great colonising country has been without telegraphic communication with the Cape so long. We all know that the extension of commerce is the best civilising influence you can carry out with regard to these new colonies, and I am sure that it would give great pleasure and encouragement to the commercial interests, not only of Scotland, but of England and Ireland, if we had that communication. You are aware that a telegraphic communication would give facilities for extending our commerce with those South African colonies, and would not only make our trading relations with regard to that great and extensive country of South Africa more firm and speedier, but it would be the means of developing up a very much larger portion of the country than is now the case; and I hope the Government will embrace the opportunity now offered to them, and, irrespective of making that country a great empire for commercial purposes, bring home to those out there gratitude by having this work done and carried out with all despatch by establishing direct communication with the Cape.

Sir BALDWIN LEIGHTON, M.P.: Sir Michael, this is, as you are aware, a deputation coming from both sides of the House, and its meaning can, therefore, be unmistakeable. For myself, speaking as a supporter of the Government. I believe I may say that the majority present here to-day are from either side of the House, and the knowledge of that fact will, no doubt, guide you in any course you may feel it right to pursue.

Sir GEORGE BALFOUR, M.P.: I can well remember, in times of great

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difficulty and danger, the great advantages which telegraphic communication had in a military point of view; and I am sure that, if you had the same feeling that I had on hearing of the late disasters, it would be deep regret that we had not had the information more speedily communicated to us of that sad event which has recently occurred in South Africa. I hope in a short time, however, that you will be able, by means of a telegraphic cable, to dispense with the sending out of more troops, for I am sure that when it is established the telegraph will convey such information to you of the real state of things that it will justify you in withdrawing many of the troops already sent from the field, the cost of whose maintenance would pay for a telegraph wire in a short time. I am quite sure that rapidity and certainty, in a military point of view, is of great importance; and, therefore, I appear here to urge upon you to establish without delay that communication with the Cape.

Sir SYDNEY WATERLOW, Bart., M.P.: I agree, Sir, that we are here to promote an object in which all classes of society feel the deepest interest. It would ill become me to say I have any right to speak here on behalf of the city of London, but I trust, having been connected with the trade in the City for the last thirty years, I may say with confidence that a large number of merchants in London interested in the development of commerce between this country and the Cape would hail with the liveliest satisfaction the news that the Government could see their way to establishing a telegraphic communication between this country and Natal. But I will point out what, I venture to think, is the economical point of view in which the Government find themselves. You will admit that it is quite possible that this war in Zululand may last for a considerable time. It may not be easy to stamp it out for a great time. Provisions and supplies may have to be sent in abundance; and no one knows better than you, that if you can have rapid communication you may save tens and hundreds of thousands of pounds in being able to send out what is wanted, and avoiding sending what is not required. At present the Government have to speculate to a great extent on what is really wanted: whereas if they knew twenty-four hours beforehand what was required there could be no mistake, and they would know what was wanted, whereas from want of proper communication that which is most wanted may not be sent, and *vice versâ*; and the lives of our troops may be unnecessarily jeopardised. It is very desirable, therefore, that if the Government can see their way to effect telegraphic communication, it would be in the interests of the nation that it should be done as soon as possible [hear, hear].

Mr. BLAINE: As one connected with the mercantile interest of the Cape Colony, I have great pleasure in attending this deputation. It appears to me that a great advantage must accrue to the colony in being placed in closer communication with this country; but rather than let one's mind dwell upon the disadvantages which must arise from the absence of it, I would say that I know that some merchants some time ago viewed with a great degree of fear and disappointment the establishment of telegraphic agency with the colony owing to the great changes which it must necessarily effect in the ordinary course of business; but I confess no misgivings of such a character myself, nor do I think that those connected with the trade of the colony, whether resident here or out there, would view otherwise than with the greatest respect the establishment of telegraphic communication with this country. I will only at present dwell on one of the disadvantages which occur to my mind in the absence of telegraphic communication, and it is that, in my opinion, it has tended in a great measure to retard the stream of emigration to that colony, which possesses such unbounded natural resources; it has tended to retard the emigration of the more intelligent classes who look upon going to a colony not having telegraphic communication with the mother country, as going beyond, more or less, the pales of civilisation. I speak with considerable knowledge of the native character, and I can assure you that a satisfactory and final settlement of this native question will come about by adopting measures which will tend to fill up that colony with a white population [hear]. Not only as providing the means of defence, but tending to extend the beneficial influence of civilisation amongst the native tribes, than which, as a commercial man, I may, perhaps, be allowed to say there is no greater aim in the universe [hear, hear]. Holding the views, therefore, of the Cape colonists, I express my extreme satisfaction at the contemplated establishment of telegraphic communication.

Mr. W. H. JAMES, M.P.: With reference to the political and commercial considerations which have induced the deputation to come here to-day, the few observations which I wish to make may, perhaps, more accurately be described as being to some extent more personal. I have in the course of my relations with my friends discovered some of those who have sons and relatives that fell in the late disaster, and others who are engaged in the war, and, from circumstances which have been brought within the last few days under my notice, I cannot express to you as fully as I should like in the presence of this deputation, the feelings of torture and misery which those persons are now undergoing. Were I to do so, I feel sure it would go a long way towards assisting you in establishing the communication we seek at your hands [hear, hear].

Sir MICHAEL HICKS-BEACH in reply said: I think, in the first place, I ought to express my acknowledgments to you for having waited upon me to-day, constituting as you do a deputation perhaps as influential and representative in character as ever waited upon a Minister. I quite understand that it is not the desire of any gentleman present to attempt any expression of opinion as to the events which have recently occurred in South Africa. I feel that you agree with the view which I think is, practically, unanimously taken in Parliament, that, in fairness to those who are absent, the expression of any opinion should be withheld until the history of these events is fully known [hear, hear]. Your wish is, I think, merely to show, from what has occurred, the excessive and urgent importance upon political and military, as well as commercial grounds, the necessity for the establishment of telegraphic communication with South Africa [hear, hear]. I do not understand that you come here as blaming me or Her Majesty's Government for anything they have done or left undone in this matter. I think you are aware that I, and, I may add, my predecessor in this office, have taken an active and an earnest interest in this question, and I hope have done what lay in our power to promote the establishment of this communication. The time has now arrived when the necessity for that communication will, I may say, be almost unanimously acknowledged throughout the country, although, perhaps, such a view might not have been taken even a year ago [hear, hear]. And I think it will be admitted, as has been said to-day, that it is useless and would be wrong for us to wait in the hope that such communication would be established by individual enterprise; and that it would be right for the country to take some share of the burden of establishing it upon itself [hear, hear]. Now, you do not, I think, wish to express any definite opinion of your own as to the mode in which such communication should be established [hear]. I may say that the Departments of the Government which are principally concerned, namely, this office, the Treasury, and the Post Office, have now before them more than one definite proposal for the execution of the work on certain terms, and for its commencement at once; and we shall lose no time, I can assure you, in arriving at a decision on these proposals, which are under our most careful examination. It is our duty, and we shall try to make the best bargain for the country in our power; but it is also our duty to see that no unnecessary time is lost in making that bargain [hear, hear]. I have only to add that I hope before many days are over we may be in a position to announce that some arrangement has been concluded, and that the strong concurrence of feeling that has been expressed here to-day by gentlemen sitting on different sides of the House of Commons, and representing, practically, all the varied interests in the country, is no slight inducement for me to hope that Parliament will favourably receive such proposals on the subject as we may feel justified in putting forward [hear, hear].

The deputation thereupon retired.

JERSEY AND GUERNSEY TELEGRAPH COMPANY (LIMITED).

The adjourned extraordinary general meeting of this Company was held on the 20th inst., at the offices, 26, Budge-row, Mansion-house, E.C., Mr. Lefevre in the chair. Previous to the commencement of the proceedings, Mr. Ford, on the reading of the minutes of the previous meeting, objected to them as not being correct, and they were not signed by the Chairman. The Chairman said that at the previous meeting an amendment was moved to the motion for the adption of the accounts and the dissolution of the Company, to the effect that Mr. Church be appointed auditor and the meeting be adjourned for a fortnight for the presentation of further accounts to the shareholders. That amendment was carried with three dissentients, but he held that his resolution was carried by proxies [cries of "No, no no"]. He might mention that the petition to the Court of Chancery for the compulsory winding-up of the Company had been dismissed without costs. He also stated that Mr. Ford had commenced legal proceedings against the directors in regard to various transactions of theirs in connection with the Company. He should now simply move the former resolution, viz., "That the shareholders hereby adopt and confirm the final balance sheet this day submitted to them, and declare the Company is finally wound up and dissolved." The motion having been seconded, Mr. Church said that although he had been appointed auditor at the previous meeting, he had been refused access to the books of the Company. He was consequently unable to lay any further accounts before the shareholders. Some angry discussion ensued, in the course of which the conduct of the directors was strongly censured, no accounts having been presented since 1872, and those only having been entered on the minutes and not circulated amongst the shareholders.—Mr. Ford and Mr. G. N. Strawbridge asked to see the balance sheet of 1872, to which request the Chairman refused his consent.—Mr. Ford thereupon protested against the legality of the proceedings, and retired from the room.—The Chairman then put his resolution, which he declared to be carried, but what appeared to be a large majority of the shareholders refused to vote on account of the illegality of the meeting. The proceedings then terminated.

RECENT PATENTS.

953. ELECTRO-MAGNETIC MACHINES, *J. H. Johnson.—Dated 9th March*, 1878.—*(A communication.)* 6*d*.

A series of electro-magnets are arranged radially around a common centre, and formed in one with a central shaft, to which motion is imparted by an external pulley. The magnets are charged by any suitable current. A fixed ring of soft metal covered with copper wire, wound round it spirally, encircles the system of magnets. A frame of two plates, a base, and several cross bars supports the ring, and also the bearing for the shaft. The core of the ring, instead of being in one piece, is composed of iron wire covered with insulating material. The covering of copper wire is divided into any suitable number of sections.

2202. TELEPHONES, *W. H. Preece.—Dated 1st June*, 1878. 6*d*.

The reciving instrument consists of a polarised relay, whose armature, vibrating in unison with the original source of sound, will, by its connection through a wire with the diaphragm of a drum similar to that of the toy telephone, reproduce the transmitted sounds. In order to increase the sound, the free end of the armature is extended beyond the relay, so as to give that end an amount of motion greatly in excess of that requisite for making and breaking contact, and by connecting the diaphragm with this free end by means of a wire, the amplitude of the vibrations is multiplied.

2396. TELEPHONES AND APPARATUS EMPLOYED IN ELECTRIC CIRCUITS. —*T. A. Edison.—Dated 15th June*, 1878. 10*d*.

The sound waves act against a plate to which a carbon button placed in the electric circuit is connected. The circuits are arranged to bring into action one or more primary and secondary currents, and an induction coil, and switches and a call, so that signals can be sent and messages transmitted in opposite directions over one line. The receiving instrument has an electro-magnet, and an armature formed of an iron plate, and a hammer is attracted or repelled so as to strike thereon and form a call. Two or more vibrating instruments, connected in the same circuit and operated by electro-magnets, are thrown out of the circuit by a shunt, and act to give signals in two distant instruments provided with diaphragms.

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2399. OBTAINING LIGHT BY ELECTRICITY, *W. P. Thompson.—Dated 17th June*, 1878.—*(A communication.)* 6*d.*

A long carbon pencil is guided by an insulator near the lower part, and a pivot at the top, which, by its own weight, and the weight of its attachments, presses the stick of carbon downwards. On the vertical attachment of the pivot is a rack, on which works a train of gearing of rapidly increasing speed, attached to a disc of carbon, upon the edge of which is supported the pivot or end of the carbon pencil. Some distance from the end of the pencil a platinum or other conductor is pressed against it, and the disc forms the other conductor.

2401. APPARATUS FOR PRODUCING ELECTRIC LIGHT, *C. Dubos.—Dated 17th June*, 1878.—*(Not proceeded with.)* 2*d.*

In order to adjust the carbon points, one of them is mounted on a soft iron rod, guided to slide through the middle of a coil that is in the electric circuit. The weight of the slide tends to move it in one direction, and the attraction of the coil when the current passes through it tends to move it in the opposite direction.

2408. TORPEDO BOATS, *W. R. Lake.—Dated 17th June*, 1878.—*(A communication.)* 6*d.*

This relates to improvements on patents, No. 747, dated 22nd February, 1878, and No. 1303, dated 2nd April, 1878, and consists in forming the hull of a central portion for containing the magazine, the chamber for the cable, and the compartment containing the steering apparatus; and the side or auxiliary portions, forming the reservoir for the gas and the propelling engines, the screws or propellers being arranged at the stern of the side portions, and are rotated in opposite directions. A water chamber is formed in the hull, which the operator may cause to fill with water in order to submerge the boat. When wished to raise it again the operator can admit gas to an auxiliary engine in connection with the water chamber so as to force out the water, when the boat will rise again. The cable through which the current is transmitted for actuating the various devices necessary may consist of a single wire, connected with a multiple or compound relay; but it is preferable to have one wire for all operations, exclusive of firing, and to employ a separate insulated wire for the latter purpose.

2438. GRAPHITE THERMOMETERS AND PYROMETERS, *O. Steinle.—Dated 19th June*, 1878. 6*d.*

This consists in the use of a car of graphite or plumbago enclosed within a tube, which tube being liable to change in length by difference of temperature, is caused to act on the indicator by means of a tube extending from the top of the said bar to the indicator.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES FEB. 26.		BUSINESS DONE WEEK ENDING FEB. 26. Highest.	Lowest.
Anglo-American	59,	½	59½	58¾
Do. "B"	86½,	87	87	86¼
Do. "A"	31,	¼	31¼	31
Brazilian	6¾,	¼	6 15-16	6¾
Cuba	8½,	¾	—	—
Do. Ten per Cent. Preference	15½,	16	—	—
Direct Spanish	1⅝,	2	—	—
Do. Ten per Cent. Preference	10,	⅛	—	—
Direct United States	11½,	¾	11¾	11¼
Eastern	7 5-16, 7-16		7 7-16	7 5-16
Do. Six per Cent. Debenture	104,	107	—	—
Do. Five per Cent. do.	100,	103	—	—
Do. Six per Cent. Preference	11¼,	½	11¾	11½
Eastern Extension	7 5-16, 7-16		7 7-16	7 5-16
Do. Six per Cent. Debenture	105,	108	107	—
German Union	7⅞,	8¼	7⅞	—
Globe Telegraph and Trust	4 15-16, 5 1-16		5 1-16	4¾
Do. Six per Cent. Preference	10⅜,	½	10½	10⅜
Great Northern	8½,	⅝	—	—
Indo-European	20,	21	—	—
Mediterranean Extension	2⅞,	3¼	—	—
Do. Eight per Cent. Preference	9,	¼	—	—
Reuter's	9⅞,	10¼	—	—
Submarine	215,	225	221¼	221
West India and Panama	1⅞,	2¼	2	—
Do. Six per Cent. Preference	8½,	¼	8¾	—
Western and Brazilian	4⅛,	⅜	4¾	4 1-16
West. Union Seven per Cent. 1st Mort.	114,	118	—	—
Do. Six per Cent. Sterling	102,	104	—	—

TRAFFIC RECEIPTS FOR JANUARY, 1879.

COMPANIES.	Jan. 1879.	Jan. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,900 estd.	3,001	—	101
Direct Spanish Telegraph Company	951	944	7	—
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	24,695	22,905	1,790	—
Eastern Telegraph Company	39,226	41,531	—	2,305
Great Northern Telegraph Company	13,856	13,511	345	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	2,125	1,725	400	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

NOTICE IS HEREBY GIVEN that the FIFTEENTH ORDINARY MEETING of the Shareholders of the TELEGRAPH CONSTRUCTION and MAINTENANCE COMPANY (Limited) will be held at the TERMINUS HOTEL, Cannon-street, E.C., on TUESDAY, the 4th day of March, 1879, at ONE o'clock in the afternoon precisely, to receive a Report from the Directors, and for the ordinary business of the Company.

The Registers of Transfers will be closed from the 24th instant to the 4th March, 1879, both inclusive.

By Order,
W. SHUTER,
Secretary.

38, Old Broad-street, E.C.,
February 24th, 1879.

TO ELECTRICAL INSTRUMENT MANUFACTURERS, AND OTHERS.

J. FRANKLIN NASH, Designer and Engraver on Wood, executes every description of scientific engraving. Diagrams, copies from models, and photographs carefully engraved; strict attention being paid to detail. Estimates forwarded free of charge for all kinds of drawing and engraving connected with electricity. Fac-simile of signature, useful for letter-press printing, stamping, and marking, supplied for 3s.

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IMPORTANT TRADE NOTICE.

The only Novelties in the market this season are specialities produced by the **Scientific Toy and General Novelty Company**, and they are so startling, so original, and so wonderful, that each one will create a perfect furore, not only in the family circle, but the scientific world also.

The four following novelties for this season will be ready for delivery on December 1st:—

The "CORPSE CANDLE" or "SEPULCHRAL LIGHT." Price 1s. 6d., post free 1s. 8d.

Fits on any gas burner; automatic action; instant and horrible effect; turns all living persons into skeletons, and bleaches the brightest colours, causing one ghastly hue to pervade the entire room, where a moment before all was life and gaiety.

CLEOPATRA FIERY PELTS. Price 1s.

These pelts are blown from a tube specially made for the purpose, which can be carried in the poeket. The Pelts are ignited as they are blown from the tube, and the effect is gorgeous as they fly through the air. Nests of scorpions, coloured lights, shells, and fountains of fire startle all beholders, yet no one knows from whence they come. The intelligent policeman will be perfectly powerless, and will invariably take up the wrong party.

Collapsible Combustion Blowpipe. Price 1s., post free 1s. 3d.

These Pelts cannot be sent by post, but they can be ordered through any Stationer, Optician, or Toy Dealer.

ELECTRIC GRANULES, or PRISMATIC VITAL GERMS. Price 1s., post free 1s. 2d.

This marvellous composition will astonish the world of science. A few grains of powder are sprinkled in a basin of water, and instantly they start into life, millions of tiny tendrils or roots then shoot out in all directions, and the fairy vegetation created glistens with every colour of the rainbow. A tiny glass wand is dipped in another chemical, and the surface of the water touched, when instantly the entire vegetation springs away in all directions, and clings to the side of the basin as if in terror of the mysterious wand, and nothing will induce it to return while the wand remains near the surface.

THE GALVANAPHONE or ELECTRIC SONGSTER. Price 10s. 6d.

This wonderful instrument will startle the scientists, for we have accomplished that which all others have hitherto failed to do. We scorn to call this a telephone, as the name would cause it to be classed with those amusing and harmless instruments. The "GALVANAPHONE" is about the size of the mouthpiece of a Bell Telephone, and a song can be sung through the transmitter either one hundred yards or one hundred miles away, and the "GALVANAPHONE" will repeat the song so loudly that conversation cannot be carried on in the room. This astounding effect is produced with the greatest ease, and will undoubtedly become the telephone of the future. Part songs or glees sound equally well, and the effect is most comical to hear several voices coming through one mouthpiece. The apparatus consists of Galvanaphone, transmitter, powerful battery, and connecting line wire.

Our new chromo-litho Catalogue, 60 pages of illustrations, contains 300 conjuring tricks: also all the Chemical, Magical, Pyrotechnical, and Diabolical Novelties we manufacture.

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SUN WORKS,
32a, COW CROSS STREET, LONDON, E.C.

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NOTES.

"The Telegraph in America," by James D. Reid.—We are compelled to defer our *first* notice of this work till next week.

Companhia Telegraphica Platino Brasileira.—The confirmatory general meeting of this Company is to be held on the 14th inst., at 66, Old Broad-street.

Cuba Submarine Telegraph Company (Limited).—The number of messages passing over the lines of this Company during the month of February was 2,523, against 2,399 in the corresponding month of last year.

The Severn Bridge.—The contractors for the Severn Bridge have availed themselves of the electric light. They have two objects in view, viz., to proceed without intermission with the last large span, which is the middle one, and to provide a good light, so as to impede the navigation of the river as little as possible.

The Electric Light at Devizes.—The town hall at Devizes was illuminated by means of an electric light of 1,200 candle power on the occasion of the annual *soirée* of the Devizes Scientific and Literary Institution. The current was provided by a Siemens dynamo-electric machine, driven by an eight-horse power portable engine. The expenses in connection with the electric light were £15 12s.

The Franklin Institution.—At a recent meeting Professors Houston and Thomson illustrated the possibility of transmitting power over long distances through small wires by means of electricity. The currents of high electromotive force generated by one machine were conveyed through two fine wires, whose combined area was only equal to ·004 inch, to another machine, which in turn gave off considerable power.

The Avonmouth Docks Lighted by Electricity.—In consequence of the success of the experiments at the Avonmouth Docks, it is decided that the electric light shall be permanently adopted there. The entrance channel will be illuminated by two Lancaster lamps placed on a turret on the pierhead at a height of twenty feet above the level of the quay, and provided with reflectors suitable for throwing light along the fairway as far as the outer lock gate, and the arrangement will be moveable on a turntable. A Wallace-Farmer lamp will be used at each pair of gates, and arrangements made for directing the current to each lamp in succession as a vessel is passing through the channel.

Gray's Telephone Patents.—An Associated Press dispatch from Washington, D.C., of the 1st inst., states that the Patent Office, on the 28th of January, reissued to the assignees of Elisha Gray a patent for telephones, first granted to him July 27, 1875, which is earlier in date than any patent for telephones issued to Professor Bell. This reissue is claimed to cover the fundamental principle and the substantial mechanism of the Bell telephone and of all other telephones in use. It is controlled by the American Speaking Telephone Company, a corporation organised in the interest of Mr. Gray and of the Gold and Stock and Western Union Telegraph Companies, and it is said to be their intention to enforce it immediately against all persons making or using other telephones than those of the American Speaking Telephone Company.

Electric Light in Russia.—In the boiler shop of the Nevsky Locomotive Works, in Petersburg, the electric light was tried some days ago during several evenings. In one case two Gramme machines were used for two lights. Some experiments were also executed with three lights, when an extra machine was working. The light was very pleasant, the shop was well illuminated. Regulators, on Serrin's system, were used; and per hour every light is stated to cost about 6d. The machines and regulators for the lighting of this shop cost about £300. The shop uses at the present time twenty-four big mineral oil lamps, the maintenance of which is certainly dearer than the electric light; as, at the present time, and in future if the electric light is to be in constant use, the use of candles or small oil-lamps cannot be avoided, as the work in the interior of the boilers, during the fitting of them, requires this sort of lighting.

The Davy Centenary at Penzance.—At a lecture given in the St. John's Hall on this occasion the electric light was shown. The following is a report from the *Cornishman*:—"The electric light was lighted, to the complete astonishment and eventually the admiration of all those present who had never seen it before. Many were the looks all round, to see the effect on ceiling and floor, decorations of the room and human face divine. But the light will certainly have to undergo several changes or modifications yet, until it is generally accepted; especially is this desired by the ladies, some of whom evidently considered its effulgent rays too strong for their complexions, and, consequently, took means to prevent any injurious effects by shading their faces with their fans, or programmes. It is also too strong for the naked eye to look upon for any time, unless one is possessed of the proverbial eagle-eye, which looks the sun in the face without winking."

Börnstein's Researches on the Influence of Light on the Electrical Resistance of Metals. (*Züricher Vierteljahrschr* xxii., 1878.)—Herr Weber's experiments have led him to the conclusion that the resistance of a platinum wire is not affected by the passage of a current of less intensity than 6 units. Börnstein, on the other hand, in his experiments on the influence of light, found, with weaker currents than this, differences in the resistance to the extent of more than 1 per cent. In such a case, however, exact measurements would be out of the question, a fact which, perhaps, Börnstein did not take into account. The variations in the resistance caused by light are, in Börnstein's measurements (obtained by means of a Wheatstone Bridge) so minute that they verge upon the limits of error of observation. Besides, during the illumination there was in six cases a decrease, in seven an increase, the decrease only resulting from an average ef the whole. Putting aside a single observation, the decrease would become an increase. Börnstein's method of working takes no account of errors arising from change of temperature. Thus, Weber agrees with Siemens and Hausemann that Börnstein's conclusions are not yet justified by his experiments.

Potential v. Tension.—In the discussion of this question it may be well to bear in mind the following sentences from the preface of Clerk Maxwell's treatise on "Electricity and Magnetism." He says, "When I had translated what I considered to be Faraday's ideas into mathematical form, I

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found that in general the results of the two methods coincided, so that the same phenomena were accounted for, and the same laws of action deduced by both methods, but that Faraday's methods resembled those in which we begin with the whole and arrive at the parts by analysis, while the ordinary mathematical methods were founded on the principle of beginning with the parts and building up the whole by synthesis. I also found that several of the most fertile methods of research discovered by the mathematicians could be expressed much better in terms of ideas derived from Faraday than in their original form. The whole theory, for instance, of the potential, considered as a quantity which satisfies a certain partial differential equation, belongs essentially to the method which I have called that of Faraday. According to the other method, the potential, if it is to be considered at all, must be regarded as the result of a summation of the electrified particles divided each by its distance from a given point."

Use of Electrical Apparatus in Acoustical Research.—In a paper presented to the Royal Society at a recent meeting, Messrs. McLeod and Clarke described some experiments they had made with a view to determine the absolute pitch of tuning forks. The time measurer adopted consisted of a compensated pendulum, worked by electricity, the impulse being given by a driver depending for its action on gravity alone. The pendulum was arranged to give second contacts, driving a clock wheel with sixty teeth. This wheel had a platinum pin giving minute contacts, but it was used merely as a switch, the circuit being closed by the pendulum itself. The current worked a relay, and closed the circuit required. The tuning fork apparatus consisted of a brass drum resting on friction wheels, and driven by a weight and train. Uniformity of motion being of great importance, an air-regulator, consisting of a fan enclosed in the lower compartment of a cylindrical box was employed. By means of a diaphragm and vanes the fan could be made to do more or less work by pumping air from the lower into the upper compartment. The fan spindle carried a pulley driven by a thread passing round the drum. An electric counter gave the number of complete revolutions accomplished by the drum in any given period, and a fine-pointed tube, containing magenta, carried by a saddle above the drum, and being actuated by an electro-magnet, made a dot on a piece of white paper wrapped round the drum at the beginning and end of the experiment. The distance apart of these dots gave the additional fraction of a revolution accomplished by the drum during the period of the experiment. Electric circuits were so arranged that a reverser turned a few seconds before the minute at which it was intended to begin the experiment, causing a current to be sent exactly at that minute by the clock relay, which started the electric counter, and also made a dot on the drum. Just before the expiration of the last minute of the experiment the reverser was turned in the opposite direction, and at the expiration of that minute the counter was stopped, and a second mark made on the drum.

Vibrations of the Plate of a Bell's Telephone.—Experiments have been made by M. Henri Dufour to determine the vibrations of this plate. The first method employed consisted in transmitting the vibrations to a gas-flame. For this purpose the wide-mouthed bell of the telephone was replaced by a cylindrical one of small capacity. A cork, pierced with two holes through which passed two kneed tubes of glass, bounded within the cylinder a sort of little chamber comprised between the front face of the vibrating plate and the hind face of the cork. The illuminating-gas entered through the first tube, and issued, forming a small flame, at the extremity of the tapering second tube, so that the whole constituted something analogous to the manometric capsules which M. König places upon the pipes. Every vibration of the plate was betrayed by a movement of the flame when the induced currents employed by those produced by a small Dubois-Reymond coil, even when the exterior coil was at 2 centims. from the extremity of the inducing coil. The currents produced by the voice in a second telephone caused no variation in the height of the flame. The result was equally negative when a small mirror was borne on a kneed lever with its end resting on the vibrating plate. A ray of light reflected by the mirror did not appear to be displaced under the influence of the vibrations produced by the voice. Finally, M. Dufour tried to produce coloured rings between the vibrating plate and a lens placed upon it. For this a very thin piece of glass was placed upon the vibrating plate, in contact with the slightly convex lower face of a lens. The sounds were transmitted by the instrument, although weakened. The coloured rings were observed through a telescope furnished with a reticule. The displacement of a bright ring to the following dark one was produced by a difference in the thickness of the stratum of air equal to a quarter of a wave-length; that is to say, a change in the position of a yellow ring will be ascertained for about 0·000143 millim. displacement of the plate. This displacement is manifested by a diminution in the distinctness of the rings, which oscillate about their normal position. The displacements are observed very distinctly by employing the induced currents of a Dubois-Reymond coil, but it has not been possible to verify them for the currents produced by the voice. Having heard it said that two telephones the localities of which have very different temperatures do not work well, the author desired to put the matter to the test by direct experiment. One of the instruments was left during several hours exposed to a temperature of — 18°, while the other passed the same time in an enclosure heated to 40° C. The two instruments put in communication transmitted speech perfectly. As soon as the telephone was employed on the telegraph lines the action was remarked which is exerted upon the instrument by the currents used to work the Morse apparatus, and passing in wires near that which connects the two telephones. This action is attributable to induction-phenomenon. M. Dufour tried to ascertain the distance at which an intermittent current can produce an appreciable current in the telephone. Two copper wires, perfectly insulated, were stretched parallel over a length of 15·2 metres, and at distances varying between 15, 35, and 45 centimetres. One of the wires joined the battery and the manipulator with the receiver of a Morse apparatus; the earth-line was formed by the gas-pipes. The two extremities of the other wire communicated directly with the telephone. The current employed produced a deflection of 60° on a telegraph needle. Under these conditions all the motions of the manipulator were distinctly perceived, and the author is persuaded that a telegraphist would have understood the signs produced by the manipulator, even when the distance between the two wires was 45 centimetres. It may hence be concluded, therefore, that on telegraph-lines the noise heard in the telephone when a message traverses a neighbouring wire may be attributed, at least in part, to induced currents. This experiment may have a certain interest in the lecture-room, to show at what distance an induced current can be produced. In this respect the telephone is much more sensitive than the galvanometer.

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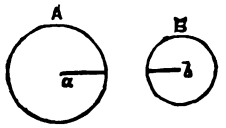
COEFFICIENTS OF INDUCTION AND CAPACITY OF TWO ELECTRIFIED SPHERES.

BY PROF. GREENHILL.*

Let a, b be the radii of the spheres A and B, c the distance between the centres, and let A be charged to potential 1 and insulated, and let B be uninsulated—that is, at potential zero. Then, with Thomson's notation (Papers on "Electrostatics and Magnetism," p. 87),



$$f_1 = 0,\ p_1 = a,\ f'_n = \frac{b^2}{c - f_n},\ p'_n = -p_n \frac{f'_n}{b},\ f_{n+1} = \frac{a^2}{c - f'_n},$$

$$p_{n+1} = -p'_n \frac{f_{n+1}}{a}.$$

Let $p_n = \frac{1}{P_n}$, $p'_n = -\frac{1}{P'_n}$.

$$\therefore f'_n = b\frac{P_n}{P'_n},\ f_{n+1} = a\frac{P'_n}{P_{n+1}};\ \text{and}$$

$$\therefore \frac{b P_n}{P'_n} = \frac{b^2}{c - a\frac{P'_{n-1}}{P_n}}.$$

Or, $$c P_n = b P'_n + a P'_{n-1}. \quad . \ . \ . \ . \ . \ (1)$$

So, also, $$c P'_n = a P_{n+1} + b P_n. \quad . \ . \ . \ . \ . \ (2)$$

From (1) and (2),

$$P_{n+1} - \frac{c^2 - a^2 - b^2}{ab} P_n + P_{n-1} = 0. \quad . \ . \ (3)$$

$$P'_{n+1} - \frac{c^2 - a^2 - b^2}{ab} P'_n + P'_{n-1} = 0. \quad . \ . \ (4)$$

Therefore, $P_n = A x^n + B x^{-n}$, $P'_n = A' x^n + B' x^{-n}$, where x is a root of the reciprocal quadratic equation

$$x^2 - \frac{c^2 - a^2 - b^2}{ab} x + 1 = 0.$$

If we put $x = e^{\omega}$, then

$$\frac{c^2 - a^2 - b^2}{ab} = e^{\omega} + e^{-\omega} = 2\cosh.\omega.$$

If we put $\frac{b^2 + c^2 - a^2}{2bc} = \cosh a$, $\frac{c^2 + a^2 - b^2}{2ca} = \cosh.\beta$, then

$$\sinh.a = \frac{h}{b},\quad \sinh.\beta = \frac{h}{a},\quad \sinh.\omega = \frac{hc}{ab},$$

where $h^2 = \frac{a^4 + b^4 + c^4 - 2b^2c^2 - 2c^2a^2 - 2a^2b^2}{4c^2}$ and $a + \beta = \omega$.

Determining the constants A, B, A', B', we find

$$P_n = \frac{1}{h}\sinh.(n\omega - a),\quad P'_n = \frac{1}{h}\sinh.n\omega;\ \text{and,}$$

$$\therefore p_n = h\,\text{cosech.}\,(n\omega - a),\quad p'_n = -h\,\text{cosech.}\,n\omega.$$

Now, q_{aa}, the coefficient of capacity of the sphere A, is the charge of sphere A when charged to potential 1, the sphere B being at zero potential; and q_{bb}, the coefficient of induction of the spheres, is the charge of the sphere B. Therefore,

$$q_{aa} = \Sigma p_n = h\,\Sigma_{n=1}^{n=\infty}\,\text{cosech.}\,(n\omega - a),$$

$$q_{ab} = \Sigma p'_n = -h\,\Sigma_{n=1}^{n=\infty}\,\text{cosech.}\,n\omega.$$

If the sphere B had been insulated and charged to potential 1, and the sphere A had been uninsulated, we should have obtained the same value of q_{ab}, and we should find,

$$q_{bb} = h\,\Sigma_{n=1}^{n=\infty}\,\text{cosech.}\,(n\omega - \beta).$$

These are equivalents to the expressions given in Maxwell's "Electricity," p. 216.

Put $a - \beta = x$, $[a + \beta = \omega]$, and $q = e^{-\omega}$; then

$$q_{aa} = h\,\Sigma_{n=1}^{n=\infty}\,\text{cosech.}\,\tfrac{1}{2}\{(2n-1)\omega - x\},$$

$$q_{bb} = h\,\Sigma_{n=1}^{n=\infty}\,\text{cosech.}\,\tfrac{1}{2}\{(2n-1)\omega + x\};$$

and, by a formula of elliptic functions,

$$q_{aa} - q_{bb} = hk\frac{K'}{\omega}\,\text{tan.am.}\left(K'\frac{x}{\omega}, k'\right),$$

where $q = e^{-\omega} = e^{-\pi\frac{K'}{K}}$, or $\omega = \pi\frac{K'}{K}$.

* Abstract of a Paper read before the London Mathematical Society on Jan. 9. Made with the Author's sanction.

This is the formula for any two spheres not in contact, $E_a - E_b = \frac{\pi ab}{a+b}\tan.\frac{\pi}{2}\frac{a-b}{a+b}$, given on p. 220 of Maxwell's "Electricity."

When the spheres are in contact, $c = a + b$, $h = 0$, $a = 0$, $\beta = 0$, $\omega = 0$; but $lt\frac{h}{\omega} = \frac{ab}{c} = \frac{ab}{a+b}$; $lt\frac{a}{\omega} = \frac{a}{a+b}$; $lt\frac{\beta}{\omega} = \frac{h}{a+b}$; and

$$q_{aa} = \frac{ab}{a+b}\,\Sigma_{n=1}^{n=\infty}\frac{1}{n - \frac{a}{a+b}} = \frac{ab}{a+b}\,\Sigma_{n=1}^{n=\infty}\frac{1}{n + \frac{b}{a+b}};$$

$$q_{ab} = -\frac{ab}{a+b}\,\Sigma_{n=1}^{n=\infty}\frac{1}{n};$$

$$q_{bb} = \frac{ab}{a+b}\,\Sigma_{n=1}^{n=\infty}\frac{1}{n - \frac{b}{a+b}} = \frac{ab}{a+b}\,\Sigma_{n=1}^{n=\infty}\frac{1}{n + \frac{a}{a+b}}.$$

The series for q_{aa}, q_{ab}, q_{bb} are infinite, but E_a and E_b are finite, for, the potential of each sphere being unity,

$$E_a = q_{aa} + q_{ab} = \frac{ab}{a+b}\,\Sigma_{n=1}^{n=\infty}\left(\frac{1}{n - \frac{a}{a+b}} - \frac{1}{n}\right);$$

$$E_b = q_{ab} + q_{bb} = \frac{ab}{a+b}\,\Sigma_{n=0}^{n=\infty}\left(\frac{1}{n - \frac{b}{a+b}} - \frac{1}{n}\right);$$

Now $\Gamma(x) = lt_{\mu=\infty}\mu^x\frac{1.2\,3\ldots\mu}{x(x+1)(x+2)\ldots(x+\mu)}$, and, therefore, denoting $\frac{d}{dx}\log\Gamma(x)$ by $\psi(x)$,

$$\psi(x) = \log\mu - \frac{1}{x} - \frac{1}{x+1} - \frac{1}{x+2} - \ldots - \frac{1}{x+\mu},\ \mu = \infty.$$

Therefore, $$E_a = \frac{ab}{a+b}\left\{\psi(1) - \psi\left(\frac{b}{a+b}\right)\right\},$$

$$E_b = \frac{ab}{a+b}\left\{\psi(1) - \psi\left(\frac{a}{a+b}\right)\right\}.$$

Since $$\Gamma\left(\frac{1-x}{2}\right)\Gamma\left(\frac{1+x}{2}\right) = \frac{\pi}{\cos.\frac{\pi x}{2}},$$

$$\therefore \psi\left(\frac{1+x}{2}\right) - \psi\left(\frac{1-x}{2}\right) = \pi\tan.\frac{\pi x}{2},$$

and, putting $x = \frac{a-b}{a+b}$,

$$\psi\left(\frac{a}{a+b}\right) - \psi\left(\frac{b}{a+b}\right) = \pi\tan.\left(\frac{\pi}{2}\frac{a-b}{a+b}\right),$$

leading to the result,

$$E_a - E_b = \frac{\pi ab}{a+b}\tan.\left(\frac{\pi}{2}\frac{a-b}{a+b}\right).$$

[These expressions for E_a and E_b in terms of ψ have been given in a Paper read by Mr. W. D. Niven before the Society, December, 1876.]

Employing $\phi(x, q)$, one of Heine's generalised hypergeometric series ("Kugelfunctionen," p. 97, 2nd edition), the author obtains the following forms:—

$$q_{aa} = h\psi(a, q) = h\psi\left(\frac{\omega + x}{2}, q\right). \quad . \ . \ . \ (\alpha)$$

$$q_{bb} = h\psi(\beta, q) = h\psi\left(\frac{\omega - x}{2}, q\right). \quad . \ . \ . \ (\beta)$$

where $$\psi(x, q) = \frac{d}{dx}\log\phi(x, q) = \Sigma_{n=1}^{n=\infty}\,\text{cosech.}\,(n\omega - a).$$

Subsequently, from (α), (β) there is got the result,

$$q_{aa} - q_{bb} = \frac{1}{2i}h\frac{K'_1}{\omega}\frac{k_1^2\,\text{sn.}\left(iK'_1\frac{x}{\omega}, k_1\right)\,\text{cn.}\left(iK'_1\frac{x}{\omega}, k_1\right)}{\text{dn.}\left(iK'_1\frac{x}{\omega}, k_1\right)} \quad (\gamma)$$

where $\frac{K'_1}{K_1} = \frac{\omega}{2\pi} = \frac{K'}{2K}$.

Using Landen's transformation, (γ) becomes

$$= hk\frac{K'}{\omega}\,\text{tan.am.}\left(K'\frac{x}{\omega}, k'\right)$$

as before.

The electrification at any point Q of the sphere A, when insulated and charged to potential 1, the sphere B being uninsulated,

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is that due to the successive images P_1, P_2, P_3. The electrification due to the image P_n

$$= p_n \frac{a^2 - f_n^2}{4\pi a} \cdot \frac{1}{PQ^3};$$

and this, expanded in a series of zonal harmonics, of which the axis is the line drawn from the centre of the sphere A to the centre of the sphere B,

$$= \frac{p_n}{4\pi a^2} \Sigma_{i=0}^{i=\infty} (2i+1) \left(\frac{f_n}{a}\right)^i Q\,i,$$

$$= \frac{h}{4\pi a^2} \operatorname{cosech}.\ (n\omega - a)\ \Sigma_{i=0}^{i=\infty} (2i+1) \left\{\frac{\sinh.\ (n\omega - \omega)}{\sinh.\ (n\omega - a)}\right\}^i Q\,i,$$

and, therefore, the electrification of the sphere A

$$= \frac{h}{4\pi a^2} \Sigma_{n=1}^{n=\alpha} \operatorname{cosech}.\ (n\omega - a) \Sigma_{i=0}^{i=\infty} (2i+1) \left\{\frac{\sinh.(n\omega - \omega)}{\sinh.\ (n\omega - a)}\right\}^i Q\,i.$$

Similarly, the electrification at any point of the sphere B

$$= -\frac{h}{4\pi a^2} \Sigma_{n=\infty}^{n=\infty} \operatorname{cosech}.\ n\omega\ \Sigma_{i=1}^{i=\infty} (2i+1) \left\{\frac{\sinh.\ (n\omega - a)}{\sinh.\ n\omega}\right\}^i Q\,i,$$

the axis of the zonal harmonic being now the line drawn from the centre of sphere B to the centre of sphere A.

The Paper closes with showing how to obtain expressions for q_{aa}, q_{ab}, and q_{bb}, as definite integrals, in the form given by Poisson.

COWPER'S ELECTRIC WRITING APPARATUS.

At the ordinary meeting of the Society of Telegraph Engineers, held in the theatre of the Institution of Civil Engineers, 25, Great George-street, on February 26, the President, Lieut.-Colonel Champain in the chair, the discussion of Mr. Willoughby Smith's paper on the "Working of Submarine Cables" was resumed by Mr. Cromwell Varley. It was found necessary again to adjourn the discussion. A paper was then read by Prof. W. E. Ayrton, on "A New Determination of the Ratio of the Electro-Magnetic to the Electro-Static Unit of Electric-Quantity," made by himself and Prof. Perry. At the conclusion of this paper, Mr. Cowper described his writing apparatus, specimens of which were shown in actual work. It is not our intention to follow Mr. Cowper in his description, but to describe in our own words, and in our own way an instrument which shows great ingenuity and originality, and is well worthy of a high niche in the Anglo-Saxon invention list. The student will do well to enter carefully into all the details of this invention, and to make as lengthy a series of calculations as his time will permit. Mr. Cowper is an engineer, and his profession necessarily leads him to study thoroughly the laws of forces as applied to mechanical structures. The laws of forces are dealt with in a fairly simple and exhaustive manner in many of our text books; and almost every schoolboy has some inkling of what is meant by the terms, "component forces, "resultant," "parallelogram," or "triangle of forces," &c., even if he is not thoroughly able to determine the answers of problems dealing with questions involving these terms. An engineer, however, has to make a special study of them. Mr. Cowper, then, having a natural desire to dabble in electricity, and having a good ground work upon which to build, comes across the problem of "telegraphic writing," or writing at a distance. With suitable mechanism, and for short distances, the problem has long been solved, as, indeed, to a certain extent and in a certain manner has it been electrically. For one mechanical arrangement we refer the reader to Prof. Goodeve's excellent treatise on mechanism. At the commencement of paragraph 20 he says, "In order to illustrate in a lecture the power of Cams to produce any required movement the late Professor Cowper arranged a model which would write the letters R I, selected probably as a compliment to the Royal Institution. The principle of this combination of Cams will be readily understood if we remember that the successive movements of a point in direction parallel to two perpendicular lines will suffice to enable the point to take up any position in the plane of the two given lines . . ." Mr. Cowper also showed a mechanical model, which enabled him to write at a short distance. The principle of this, however, differed from the one just referred to. But to proceed—the parallelogram of forces shows that the resultant of two forces represented by adjacent sides of the parallelogram is represented by the diagonal of the parallelogram, both as regards magnitude and direction.

In the accompanying diagram, Fig. A, let A B, A C represent two forces, then A D represents in direction the resultant of these two forces; take any point, E, in the direction of the resultant. If the force A B be changed to A B^1 by a continuous change, and A C be similarly continuously changed from A C to A C^1, then the direction of the resultant gradually changes from A D to A D^1, and it will at once be seen that as the resultant changes position any point in it, as E, changes position also, and finally, as in the diagram, has the position E^1. Now, by a proper arrangement of the forces, the point E can be made to take any position, and if the forces can be continuously changed the position of E can be also constantly changed. Mr. Cowper's problem then became:—Given two forces, to so continuously change them that a point in the direction of their resultant may be controlled, and its position changed as may be desired. That the change must be continuous and not at intervals, for the purpose of obtaining written characters, will be seen by a little study.

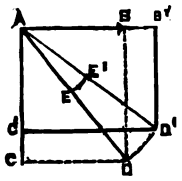


FIG. A

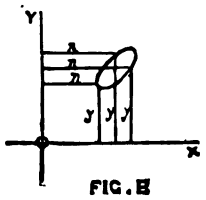
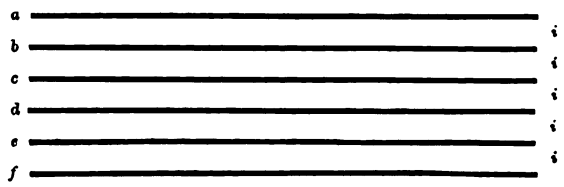


FIG. B

In the diagram Fig. B, the forces represented by x and y must vary continually, in order that the points in the curve representing the letter o may one after the other be in the direction of the resultant of the two forces. It will also be seen from the diagram that there is no difficulty in calculating exactly what the relations of these two forces must be in order to obtain these various alterations in the direction of the resultant.

The two forces which Mr. Cowper manipulates at will are due to a current of electricity, and the motion given to a part of his apparatus by the action of the two forces is translated into the lines and curves of letters, similar to the lines and curves of letters written at a distant station, the writing of which regulates the variations in the forces.

In the accompanying figures let our attention be first directed to Fig. 4. The black lines of the diagram represent a series of metal plates, arranged as a, b, c, &c., with



insulating material separating one plate from the other. Thus the spaces i, i, i, i are filled with paper soaked in paraffin. The plate a is connected directly to the line wire; b is connected to a through a resistance coil; c is connected to b through a resistance and so on. Suppose a freely moving rod R, with a metal contact

piece r to be placed on the metal plates, and moved across the plates. If the rod was connected with one pole of a battery B, the other pole of which was to earth, the other end of the line being put to earth also, we should get a complete circuit, the current going through R, r, &c., into the line wire. If the contact r rested on plate a, the current would pass directly to line through small resistance, but if r made contact with any other plate the current passing into the line would be lessened because of the increased resistance, due to the resistances between the plates. The more remote the contact from a, the greater the resistance and the less the current.

Mr. Cowper arranges two such series of plates at right angles to each other. It is not absolutely necessary that they should be at right angles, but it is convenient. The preceding argument holds good, whatever the angle may be. Having arranged his plates, the contact rods are rigidly fixed to the style or pen which is to regulate the movements, and therefore the contacts made by the rods on the plates.

The accompanying illustrations will enable the reader to see exactly how Mr. Cowper attains his object. Fig. 1 is a plan of the sending instrument, Fig. 2 being an elevation of the same. The writer holds the pen, which is rigidly connected to the travelling contacts, and also, as shown at A^1 A^2, to the batteries. The slip of paper on which the message is written is moved somewhat in the same way as in a Morse instrument; in fact, the Morse clockwork can be easily used for the purpose. Thus the paper travels under the pen, instead of, as in ordinary writing, the pen travelling over the paper. Two sets of thin metal plates, C C, form the contact apparatus; D D are the light connecting rods, the ends of which make contact with the plates; F F are

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the resistance coils connected to the contact plates, one coil for each plate, except the first of the series, which is connected direct to line. As we have already noticed, the strength of the current entering the line depends upon the plate with which contact is made by the connecting rod. As the rod travels from the first of the series the resistance increases, the current having to

FIG 2

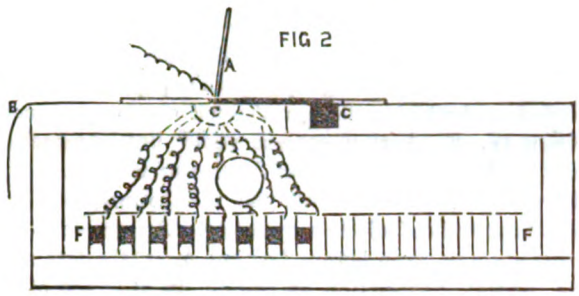
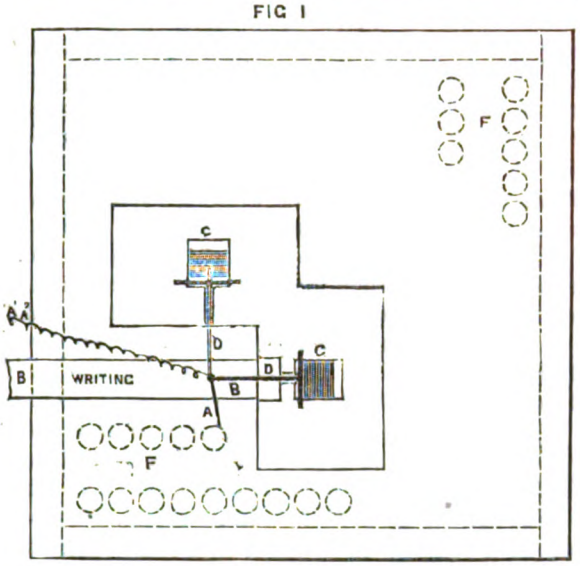


FIG 1



pass through n—1 resistance coils, as well as the line wire, n being the number of plates from the first of the series to the point at which contact is made. Generally, however, as one contact piece travels from the first of the series, the other travels towards the first of its series, and thus, while the current varies decreasingly in one line, the variation in the other is an increase. Figs. 3 and 4 show respectively an elevation and plan of the thin

FIG. 3.

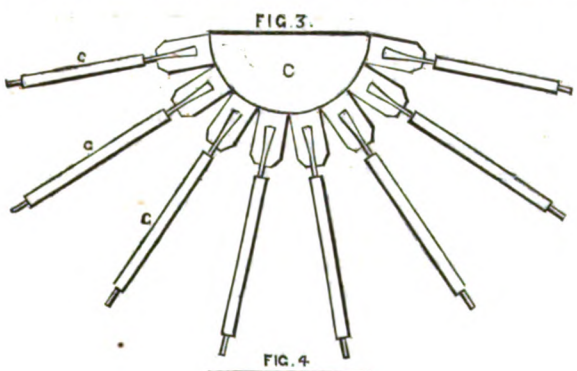
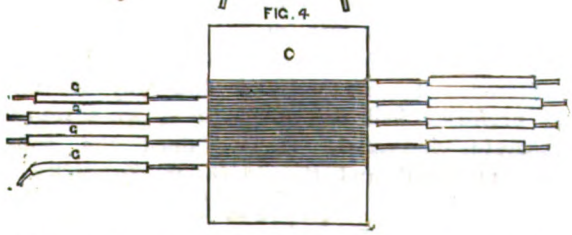


FIG. 4



metal plates, which are insulated the one from the other by paper soaked in paraffin.

The receiving instrument, shown in plan and elevation in Figs. 6 and 7, differs from the sending instrument; H, H are light soft iron bars on delicate bearings, having the ends surrounded by the coils I, I, to which the bars form a movable core. Through these coils the varying currents of the line are sent, which, of course, have a varying action on the core. J, J, J, J, are four permanent or electro-magnets, between the poles of which the coils just named are placed; K is a syphon pen. Mr. Cowper prefers, but does not restrict himself to the use of, the well-known syphon pen of Clark. The pen is adjustable from the bridge L and the ink reservoir is shown at M. The light connecting rods N, N, transmit the motions of the movable cores to the pen; o, o, are springs to enable the pen to resist the pull of the magnets, the connections are shown in o^1, o^2, o^3, the latter being attached to a fixed post o^4.

As the currents sent through the line wire by the sending instrument vary in strength or power, and cause the light bar of soft iron to move with varying power by its attraction to the stationary magnets; and in order to cause it to take its proper position according to each variation in power, a varying resistance is opposed to it, such as a spring which requires more power to compress it the more it is compressed, that the action of the soft iron bar, combined with that of a precisely similar bar actuated by the second line wire, will cause the position of the pen in the receiving instrument to follow the position of the pen in the hand of the operator at the sending

Telegram from our own correspondent

FIG. 7.

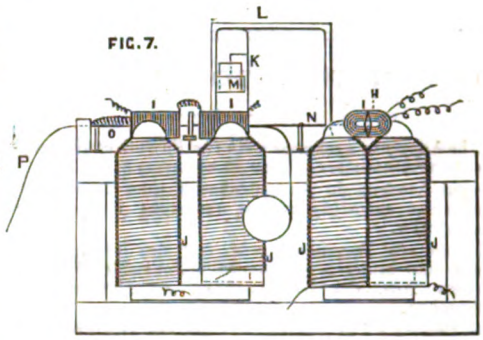
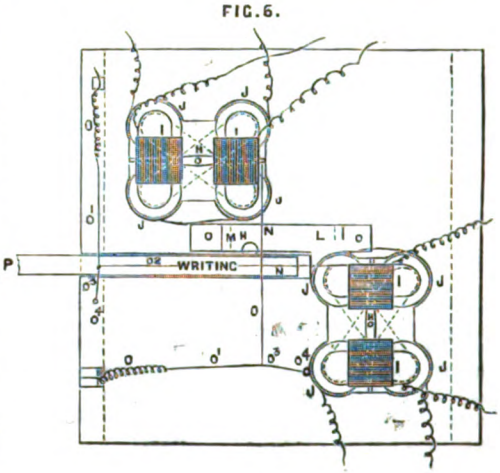


FIG. 6.



instrument, and thus form the letters. The total strength of the spring or varying resistance can be regulated at will, so that the letters formed by the pen shall be of the same proportionate height and width as the letters written by the operator at the sending instrument. One convenient way of applying the varying resistance to the light bar of soft iron is by placing a very light spring to pull at the end of the bar in the direction of its length, but allowing of the motion of the bar, which will thus cause the spring to act with more and more leverage as it moves more out of line with the spring. When so arranged there is required another spring to keep the connection with the pen tight, if such connection is flexible, so that the pen may go backwards as well as forwards over the paper, as the light bar of soft iron moves either one way or the other. But the spring or variable resistance may be made to act both to give the increasing resistance and the power to draw back the pen as well, if the spring is made to pull by a flexible or jointed connection at a fixed point, the line of such pull being parallel, or nearly so, to the light bar of soft iron, while another rigid or flexible connection from the end of the bar to the connection to the spring has the pen attached to it at about the middle of its length, which arrangement will give the same result as the two springs before described.

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THE ELECTRICIAN.

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THE MEETING OF THE SOCIETY OF TELEGRAPH ENGINEERS.

At the meeting of the Society of Telegraph Engineers on Feb. 26, one of the most interesting pieces of electrical apparatus that has recently been invented was described and shown. The large theatre of the Institution of Civil Engineers was fairly well filled, but it ought to have been crowded. This meeting of the society was unique of its kind; it is, indeed, doubtful if another such meeting will gather during the session. It was with very great pleasure the members saw Mr. Cromwell F. Varley once more taking an active part in the work of the society. Mr. Varley is a master of his subject, and whatever he says is worthy of careful consideration. His comments on, and extension of Mr. Willoughby Smith's paper will be looked forward to with some anxiety in the forthcoming number of the journal. We may here notice the praiseworthy efforts that are being made to issue the journal regularly and at frequent intervals to the members. Although we give our readers as full an account as we can of the meetings of the society, it is, of course, impossible for us to do more than give a bare *resumé* of what is read, or of the matters noticed in the discussions. Besides the discussion on Mr. Willoughby Smith's paper, which is not concluded, and which will be continued at the next meeting, Professor W. E. Ayrton gave a rapid but comprehensive account of the investigations of Professor Perry and himself to determine the relation of the electro-magnetic to the electro-static unit of electric quantity. An account of these experiments was given before Section A at the late meeting of the British Association at Dublin, an abstract of which will be found in vol. i., p. 178.

The paper of the evening, although perhaps of less importance in the long run, was that of Mr. Cowper on his Telegraph Writing Instrument. We have described this writing apparatus in another column, and therefore have no need to dwell upon it here.

Taking the meeting on this evening as a whole, it approaches more nearly to what we conceive such meetings should be than any previous one we have attended. The papers and the discussion were intensely educational, and it is time the schoolmaster went abroad in matters electrical. The mere description of an instrument or an invention, couched in the purest and best-selected language which the mind can conceive, is to the mass of us essentially uninteresting. Unless the paper and the discussion have for their aim the bringing of the why and the wherefore clearly and distinctly to the mind of the dullest amongst those occupying the benches of the theatre it fails in its object. We have often undergone the torture of listening to a long string of platitudes for an hour, and were not surprised to hear audible sighs of relief when time inexorably brought the speaker's remarks to a close. However, in the evening we have mentioned, time for once went too quickly, and this partially spoiled the excellent matter to be considered. Mr. Varley did not say all he had to say, Professor Ayrton was hurried, and had to skip part of his matter, and similarly with Mr. Cowper. This is to be regretted, and would be an incalculable deterrent to the value of the work of the society were it not that we shall read what was left unsaid in the pages of the journal. Still, the living voice has greater charms than printers' ink, however well the author and printer work together. As we say, we enjoyed the meeting because the "why" was evidently uppermost in the minds of the speakers. Mr. Varley told us why his system was calculated, and not only calculated but practically does, increase the speed of signalling in long cables. Professor Ayrton explained clearly, although hurriedly, the terms "electro-magnetic" and "electro-static unit of electric quantity." He discussed the experiments made by previous workers, pointed out their faults and their excellencies, and then proceeded to tell us how and why he and his brother professor had determined to obtain a result with the apparatus indicated. He explained the apparatus somewhat in detail, and then gave us the results. After such a description the whole research in theory and in its practical application must be brought vividly to the mind of every reader of the journal who heard the paper.

Mr. Cowper's paper, as we have shown elsewhere, was of very great value, inasmuch as it pointed out an almost new line of departure. Too many of us forget, if we ever

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knew, the intimate connection between mechanical laws and electrical applications. It was left to a civil engineer to apply the "parallelogram of forces" to the construction of an electrical instrument. This is not the only "problem" in mechanics. What others will be applied to electrical purposes, by whom and when? How clearly the meeting of the 24th of February pointed out our English conservatism, "Let well alone." We envied Japan —that unknown Eastern land—which is hurrying to introduce European science, and improve upon it. Why should we not follow in her wake, and try to extend our centres of technical instruction. We have one "School of Telegraphy" in London, where the connection between pure and applied mathematics, chemistry, &c., and electricity is specially taught; yet it is not so well known as it ought to be; while Birmingham, Dublin, Edinburgh, Leeds, Manchester, and other large towns, are dependent solely upon the instruction given in classes connected with the South Kensington Science Department for any smattering of knowledge on electrical matters.

CORRESPONDENCE.

ELECTRICAL POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have no wish to occupy your space with a useless discussion on a subject which, I venture to think, is not really an open question; but I gather from the recent letter of Mr. Desmond FitzGerald (p. 175), in reply to my communication on Potential, in your issue of February 22 (p. 164), that he has taken the expressions in that communication in rather a personal sense, and feels somewhat aggrieved thereat; I trust, therefore, that you will allow me a few words in explanation.

The fact is that I had seen in your "Notes" of Feb. 1, p. 121, the extract from the *Panthéon d'Electricité*, to which he now refers me, and also one or two other statements on the subject of Potential, which had driven me to the verge of pen and ink; and Mr. FitzGerald's letter, on p. 139, was only the last straw. Had I been replying to his letter alone, I should have mentioned him by name, and, moreover, I hope, should have adopted a rather more courteous tone. As it was, I wrote in a more general manner, and went so far as to perpetrate a sentence about "talking nonsense;" an unparliamentary expression which you, Sir, were good enough to omit.

One more word by way of explanation. I see from Mr. FitzGerald's penultimate paragraph that I was in error in animadverting as strongly as I did on the expression "density of current;" I was not aware that it was used in a perfectly definite and definable sense, viz., the strength of current flowing through unit area of a conductor. Personally I should have preferred the term *intensity*, instead of *density*, to express this (just as the *intensity* of a pressure means the pressure per unit area, and so on), but that is immaterial; the term, as defined, is, as Mr. FitzGerald says, "philosophically accurate," and may very probably be useful in electro-metallurgy.

I regret to say, however, that there is no other sentence in Mr. FitzGerald's letter with which I am able to agree.

And now, if I say any more I trust Mr. FitzGerald will acquit me of the smallest feeling of personal discourtesy, and, moreover, will believe that I have not the least hope, or even desire, of converting him and making him see the error of his ways. If he feels happy in his present stage of opinion, and can get on (as I doubt not he can) well enough for all practical purposes, I should be sorry to disturb his equanimity; but, as he speaks of *teaching*, I may perhaps be allowed to ask him to refrain from instructing his pupils more than he can possibly help concerning electrical *theory*; for, being (as he pleasantly observes) only one of the coming generation myself, I cannot help feeling some sympathetic regret for the pain and difficulty which those, and many other, students will experience before they succeed in extricating themselves from the fog in which the old fashioned terms and methods must inevitably leave them. At the same time, there are certain sentences in his letters which indicate that he has managed to arrive at some partially correct views regarding the inductive circuit through a dielectric, which, notwithstanding that they are expressed in a vague manner not easy to understand, are nevertheless so excessively important that they may be allowed to cover the bad effects of a good deal of erroneous terminology.

Referring again to Mr. FitzGerald's original letter on p. 139, I find that it is itself a reply to a letter of M. du Moncel's, translated in your preceding issue, p. 131; and on turning back to this I find a number of statements which I am just as willing to object to as Mr. FitzGerald himself can be. Some of these statements, I think, I must have cursorily noticed at the time when it was the current number, and must have classed among the other "nonsense" which had been, was being, and will still be written about electricity. I now find to my surprise that M. du Moncel professes himself a supporter of modern views; to which I can only say, "Save me from my friends!"

But here let me lay special stress upon the fact that the letter in question is only a translation, and that I have never seen the original. It is a very good rule never to judge a man without seeing his exact words—certainly never from a rough translation into another language—even though it were made by the writer himself. What I say, then, on this head, is not to be understood as in any degree hostile to M. du Moncel or his works (which I have never read), but simply and solely to the words of the translation on page 131 of your issue of Feb. 1.

The greater portion of the longest paragraph in that translation appears to be meaningless; the definition of potential attributed in a later paragraph to M. Abria is erroneous; and the paragraph concerning "the tension of a current" is absurd.

The creed of Mr. FitzGerald on the whole subject is, however, not very much more satisfactory. In so far as it can be gathered from his two letters, and in so far as it is novel and striking, it may, apparently, be formulated in the following *Sartorian* "Articles of Faith."

1. The word "tension" was used by the older writers on electricity, and is used by them at the present day with a perfectly definite and unique signification.

2. Mathematicians, with their well-known and pernicious habit of multiplying terms and using two where one will suffice, have arbitrarily invented the term "potential" to signify the same thing.

3. This word "potential" does not correspond to any real physical fact distinct from tension; it has not established usage on its side; and it is useless.

4. The tension of a charge is not greater at pointed than at rounded or flattened portions of a conductor.

5. The tension inside a hollow conductor is the same as that on the outside.

6. The fact that electricity travels like an incompressible fluid in a circuit *always* closed is not known, and the mode of using an electrometer to measure difference of potentials is not understood, in any "modern centres of learning."

7. The potential of a surface is measured by the potential energy stored up in unit quantity of electricity when accumulated under the same potential; but what the potential of a *point* may mean is a thing which nobody understands.

All which propositions I, like Diogenes, content myself with modestly but peremptorily and irrevocably denying.—Yours, &c.,

University College, London. OLIVER J. LODGE.

WORKING OF SUBMARINE CABLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have carefully read the paper on "the working of long submarine cables" by Mr. Willoughby Smith, which was read before the Society of Telegraph Engineers on the 12th inst., and I hope I shall not be considered too presumptious in freely making comments on a paper emananting from so high an authority as one "who has had to do with the subject personally and practically ever since the laying of the first successful Atlantic cable."

The history which Mr. Smith gives of the "working of long submarine cables since the present system came into operation, now some twelve years ago," is truly very interesting, and, doubtless, strictly correct, and it may remove "the very considerable misapprehensions existing as to *how* and *when* the present system was introduced," but I fail to see any explanation as to *why* it was introduced; I also fail to see how this history will make "inventors acquainted with the real state of the case," so as to save them from "worrying themselves in making strange improvements."

It is probable that inventors, who, unfortunately, have been ignorant of the working of the present system, and in their ignorance of it made many strange improvements in it, will profit by viewing the history of it, and no longer worry themselves in attempting to make improvements in it, but will turn their attention to the invention of some new system, for surely it cannot be claimed that, because the present system is the best in use, no new system can be devised which will give equally good, or even

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better results. A careful examination of this system, as described by Mr. Smith, will probably deter any inventor from attempting to improve upon it, but he should increase the defect in it, if I may presume even to insinuate that there is a defect in a system which represents the combined work of so many eminent personages; and it may lead inventors to seek for a new system among the well-established facts regarding the movements and effects of electric currents in submarine cables.

The principal and chief effect to be produced, in order to signal through long submarine cables, is to discharge the core after each signal is sent through it; and the more rapidly the discharge can be made, the more rapidly can successive signals be made through them. The present system is conspicuous for the absence of any contrivance to produce this absolutely necessary result. An attempt in this direction was made in 1865 by Sir William Thomson and Mr. C. F. Varley, who jointly patented the "curb-key," by means of which from five to seven currents, varying in kind and strength, were sent into the cable, "was to neutralise each other, and thus discharge the core for the next signalling." This "curb-key" was tried, and, according to Mr. Smith, "a disputed speed of six words a minute was with difficulty raised while sending the test message." The use of the "curb-key" was abandoned, and that of condensers was initiated, and a speed of thirteen words a minute was obtained, and this is the system which has been in use ever since.

Among the various improvements upon the system in which condensers are used, there does not appear to have been any successful attempt made to discharge the core of the cable after the failure to do so by means of the "curb-key," although it is an undisputed fact that the speed of transmission of signals depends upon the speed with which the cable can be discharged; and it is also an undisputed fact that science has clearly defined the means by which the discharge of a cable can be made in the minimum time, dependant on the duration of charge. These means have passed beyond the limits of theory, and are established facts; yet, unfortunately, the application of those means seems yet to be made.

The defect in the present system, to which I have referred above, is this absence of means to discharge the cable; the defect is inherent in the system.

To counterbalance as much as possible the evil caused by this radical defect, the attention of inventors appears to have been directed to devising instruments capable of being acted on by very weak currents, and the production of the "mirror" and "syphon recorder," by Sir William Thomson, seems to have been the *be-all* and *end-all* of progress in the way of increasing the speed of receiving signals sent through long submarine cables, and the managers of cable companies appear to be contented with the present defective system, which Mr. Smith says, "For speed, simplicity, economy, and accuracy, has never been surpassed."

If it be true that the inductive action of electricity in a submarine cable is the great and chief obstacle to the rapid transmission of signals through it, and if it be true that the use of the cable can be restored to its natural condition in a duration of time not longer than that of the charge, hence it must be admitted that the system now in use is radically wrong. Mr. Smith writes of it as follows:—"Practically speaking, none of the current passes out of the cable at the receiving end. The cable is only partially discharged between each signal by each spring of the sending key being put to earth after it has been depressed to charge the cable." And further on he writes:—"Thus the first signal is always more marked than those which follow in quick succession." These last words show the evil effects caused by the returning charge from the receiving end, which effects would be avoided if the discharge of the cable were complete.

A system to increase the speed of transmission must be sought for by applying the means which science has demonstrated, and which practical tests have established to procure the discharge of the cable in the minimum time possible; to wit, in a time not longer than that of the charge, whatever this latter time may be. This is the field for inventive genius to explore.

In a letter published in *The Electrician* of 21st December last, Mr. Richard Herring describes these means in the following words:—"When a conductor has received a charge of one kind of electricity, and is then put to earth at both ends, and also a charge of the opposite kind of electricity is sent into it from both ends, the conductor is restored to its neutral state in a duration of time not longer than that of the charge, whatever that duration may be;" and the necessary consequence is, as Mr. Herring writes, "by this means the maximum speed of transmission of separate and distinct shades or waves of electricity is obtained."

Mr. Herring has kindly permitted me to examine the devices by which these arrangements can be received, to which he referred in his published letter; and I am convinced that his system cannot fail to produce the desired results.

The system is simple and easy to work. The key which he has contrived to send alternately currents of opposite kinds into the cable, and to put the cable to earth after each impulse of electricity, performs its work efficiently by a single depression of its sole lever. The arrangements at the receiving end for sending into the cable a neutralising current cannot fail to do its duty, and the device, in discharging the earth at the receiving end, not through the receiver, but through another channel, effectually prevents the action of the discharge from affecting the receiving instrument. I do not hesitate to say that I believe Mr. Herring's system will surpass that so lucidly described by Mr. Smith in all the qualifications which he claims for it—to wit, in speed, simplicity, economy, and accuracy.—Yours, &c., INQUIRER.

London, Feb. 27, 1879.

FOUR LECTURES ON ELECTROSTATIC INDUCTION.

JAN. 16, 23, 30, AND FEB. 6.

BY J. E. H. GORDON, B.A.

(Assistant Secretary of the British Association).*

LECTURE III.—JAN. 30.

SPECIFIC INDUCTIVE CAPACITY.

In the two previous lectures we have seen that Induction is transmitted from particle to particle of dielectrics, and that its phenomena are exhibitions not of some direct action passing through the insulator, but of something actually existing in the particles of the insulator itself, that it is in some peculiar straining of these particles that the causes of the phenomena will be found. One of the first questions which now presents itself is, Do all insulators on which a given inducing charge acts suffer an equal strain, and therefore exhibit the same quantity of inductive action at the other side, or, on the contrary, does the same charge of electricity strain different insulators differently and produce induced changes of different strengths; in other words, are there in different insulators different capacities of receiving strain from a given straining charge—differences of specific "strainability"—that is, differences of *Specific Inductive Capacity?*

Various experiments, some of which I shall hope to explain to you, satisfied Faraday that the latter is the case, and that different bodies have different specific inductive capacities.

First, however, let me recapitulate a little, in order that it may be quite clear to us what is meant by the term specific inductive capacity. Let a certain charge of electricity be acting inductively across air upon a neighbouring conductor, and let the distance and sizes of the conductors be such that the strength of the charge induced on the second conductor is equal to unity. Let the whole space between the conductors be now filled with some other insulator. The strength of the induced charge will now be no longer unity, but it will have some other value. The number which represents this value is called the specific inductive capacity of the substance between the conductors; in other words, the specific inductive capacity of a substance is the ratio of the inductive action across it to that across air. Air being taken as the standard, its specific inductive capacity is called unity.

We will now examine the various methods by which, from time to time, various students of Nature have endeavoured to measure the specific inductive capacities of various bodies. Here, at the risk of being tedious, it will be necessary for me to go somewhat into details of experiments; but it will, perhaps, not be entirely without interest for us to look a little behind the scenes of the laboratory, and see the kind of difficulties which beset the inquirer the moment when, instead of, for instance, saying to himself, as a mathematician can, "Let there be a perfectly insulated charge of electricity of given strength, at a given distance from a conductor," he has to prepare himself to say to his instrument maker, "Here are working drawings of an instrument which is intended to place a given charge of electricity in a given place; this portion of the instrument is to regulate the charge, that portion to measure it, and the other portion to measure to 1-1000th inch the distance from that conductor. Can we construct this, so that every part shall do its work, and no two parts shall interfere with each other? Can we support it, so that it will not shake, protect it from dust, and yet contrive that neither the supports, nor the cover, interfere with the induction?"

As Faraday was the discoverer of specific inductive capacity, we will begin with his experiments, and, through the kindness of Prof. Tyndall, I can show you the very apparatus he worked with. Here it is: Faraday's wish was to construct a Leyden jar

* Delivered at the Royal Institution 1879.

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of which the metallic coatings should be fixed, and always in the same relative positions, while the insulator should be moveable, so that various Leyden jars could be set up, which should be exactly alike in all respects, except in the nature of their insulator, which could be made to consist either of air, glass, sulphur, or any other substance.

If such jars could be constructed, and if differences were observed in their behaviour, these differences could only be due to differences of induction through the different insulators or to differences of specific inductive capacity.

The apparatus consists, as you see, of a metal ball, which can be surrounded by a larger hollow one. The outer ball is made in two pieces, so as to allow the inner one to be placed inside it. There is a space of 0·62 inch between the surfaces of the balls. The inner ball is supported by an insulating stem of shellac passing through a hole in the outer one. A wire which passes up inside the shellac allows the inner ball to be put in connection with an electric machine, electrometer, or other apparatus.

The space between the balls contains the insulator. It may be air, as at present, or the whole or part of the space may be filled with glass, sulphur, &c. Faraday preferred only to fill half the space, and then to calculate what the effect would have been if the whole space had been filled. He, therefore, prepared his insulators in the form of hemispherical cups. Here are some of them.

He constructed two of these Leyden jars, so that he could observe simultaneously their actions with different insulators, and endeavoured to make them precisely alike. If they had not been precisely alike there would have been a difference in their behaviour which would have been due, not to difference in the specific inductive capacities of the insulators, but to differences in the shape and the size of the jars. In order to make sure that they were exactly alike, he made an elaborate series of preliminary experiments. We need not go into all the details of these preliminary experiments, but we can indicate the principle of them in a few words.

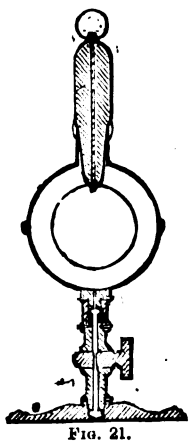

Fig. 21.

The object of them is, we remember, to determine whether the two machines have equal capacities for electricity. That is, whether under similar circumstances they will each hold an equal quantity of electricity. To determine this, Faraday first charged one apparatus only, and measured the charge. He then connected the two machines together, so that the charge divided itself between them. He then separated them and re-measured the charge of the first one. If the second apparatus had the same capacity as the first, it would have taken away exactly half the charge. If it had had a greater or less capacity, it would have taken more or less than half the charge.

The machines were, therefore, adjusted till the charge left in each after division with the second was exactly one half of the original charge before division. I have said that "the amount of charge was measured," but have not yet explained how that was done. The electro-*scopes* which we have been experimenting with only show the existence or non-existence of a charge, but they do not measure its amount. For this purpose we require an electro-*meter*. The electrometer used by Faraday to measure the induction was the invention of Coulomb, and is called "the torsion balance." Descriptions of it will be found in all books on physics. The numbers which Faraday gives as the relative strengths of electrifications are the number of degrees of twist which, for these electrifications, he read off on the torsion balance.

Having adjusted his torsion balance and determined the equality of his two Leyden jars, Faraday was ready to commence his measurements of specific inductive capacity. He kept one apparatus full of air, and placed in the other this hemispherical cup of shellac. He then compared the inductive actions through the two machines, and he at once found that the induction through the shellac apparatus was greater than that through the air apparatus in the proportion of 176 to 113, or 1·55 to 1. In this case the air apparatus had been charged first.

Another set of experiments in which the lac apparatus was charged first gave a ratio of 1·37 to 1. This difference, which is considerable, is accounted for by the fact that the experiment takes some time, and that there is a constant leakage of electricity going on, and in the one set the effect of the leakage would be to give too high a result, and in the other to give too low a one. The mean, therefore, will not be far from the truth.

Faraday, therefore, gives as his result that the induction through the apparatus half filled with shellac is 1·5 times that through the one full of air. From this he calculates that the ratio of the specific inductive capacity of shellac is to that of air rather more than 2 to 1. I have purposely avoided attempting to give the exact details of Faraday's method of working, for two reasons. One is that it is an exceedingly difficult thing to understand, as the inductive actions through the different insulators are compared by an indirect method, to follow which requires a considerable familiarity with the laws of induction, and the other is that I thought it unnecessary to burden your memories with the minor details of a method of working, which, owing to the invention of improved apparatus, no experimenter would now adopt, wonderful as it was in its day, and wonderful for all time as *are* the results which were obtained by it.

Faraday continued his experiments on other substances, and here is a general table of his results:—Shellac, 2; Sulphur, 2·24; Flint glass, 1·76 or more.

After Faraday came numerous experimenters, who have published results more or less accordant for the specific inductive capacities of many insulators. As time will not admit of my giving you an account of all the methods which have been used, and, as for three years I myself have been engaged in a determination of the specific inductive capacities of various substances, I have preferred to give you an account of my own experiments only, partly because I believe they are the latest which have been made, but more particularly as I shall be able to make a more interesting lecture about methods which I am practically familiar with, and which have, so to speak, grown up under my hand, than I could if I told you of methods which I have only read about.

First, however, let me tell you why it is so important that we should have accurate knowledge of the specific inductive capacities of the various substances whose names you see in that table,* India rubber, vulcanite, paraffin, wax, glass, &c. One reason is that these substances are much used for the insulating parts of electrical and telegraphic instruments, and unless we know their specific inductive capacity we cannot tell beforehand what their effect will be in any particular instrument. Also some of these substances are used for the insulators of submarine cables. Now, the speed of signalling, and with it, of course, the gross receipts of the telegraph company, depends, among other things, on the specific inductive capacity of the insulation, so it is as well to know this accurately before manufacturing the cable.

But there is another and to us a far more important reason for desiring accurate knowledge on this point.

Every new investigation which is made points to a close connection between electricity and light. The theory of their connection, which I shall hope to explain in the next lecture, requires a certain relation between the specific inductive capacities and certain optical properties of transparent bodies. This theory, which may even tell us what electricity is, can only be tested by an accurate knowledge of the specific inductive capacities of transparent bodies.

The experiments which I am going to tell you about have been carried on under Professor Clerk Maxwell's advice and superintendence, and he is the inventor of the new method which has been used.

The great difficulty which all previous experimenters had met with was to make the experiments quickly enough. If the electrification is allowed to continue for even 1-100th of a second all sorts of effects come in which are not due only to the specific inductive capacity of the insulator.

Three required conditions were before us when the new apparatus was being designed.

1st. The experiments must be made very quickly. This was accomplished by reversing the electrification 12,000 times per second, so that the duration of each charging of the insulator was only 1-12,000th of a second.

2nd. The electrified metal plates must not touch the insulators. When they are allowed to do so it is found that there is a leakage through the insulator which affects the results.

3rd. The method must be a zero method. That is instead of measuring the strength of two inductions separately, and then comparing them with each other we must balance the two inductions against each other till the result is zero.

As an illustration of the two methods of working let us set to work to determine the weight of a piece of butter. We ordinarily use a zero method; that is, we put the butter in one pan of a scale, and vary the weights in the other, till there is no deflection of the beam. A non-zero method, such as were the early determinations of specific inductive capacity, would have been to put the butter in one pan, a fixed weight in the other, and to have endeavoured to calculate their ratio from the deflection of the beam.

In the experiments which we are about to describe, the induction

* Table will be given at end of lecture.

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through a given thickness of the substance under examination is opposed to the induction through a thickness of air which can be varied till the two actions exactly balance. A comparison of the thickness of the air and that of the substance gives the specific inductive capacity of the latter. The same electrification being used for the two actions accidental variations in it do not affect the result.

As the apparatus before you is exceedingly complicated, we shall do better to first study this diagram where only the most essential parts are shown. We may here mention that substances across which induction takes place are called "dielectrics," from the Greek preposition διά, across. The induction balance consists of five circular metal plates, *a b c d e*, seen edgeways in Fig. 22, fixed and insulated parallel to each other, and *b c d e* are about an inch apart. The distance from *a* to *b* can be varied from about 2½ inches to nothing. *a c e* are six inches diameter, *b d* four inches. *a* and *e* are connected to one pole of the source of electricity, *c* to the other, *b* and *d* are connected to the quadrants of a Thomson (Elliott pattern) electrometer.

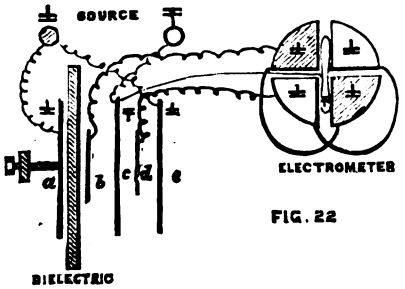

FIG. 22

At the top of the diagram are shown the two poles of the source of electricity, which are always oppositely electrified, but are constantly being reversed. The dielectric under examination can be inserted or removed at pleasure between *a* and *b*. The centre plate is also connected to the needle of the electrometer.

Let us now suppose that the dielectric is removed, and that all the plates are arranged symmetrically, viz., that distance *c b* equals distance *c d*, and distance *d e* equals distance *b a*. Suppose for a moment the reversing apparatus stopped, and the electrification to be that of the upper signs in the diagram. Let us examine the effect on the electrometer.

The inductive actions of *c* on *b* and *d* are equal and similar, consequently, the effect of *c* on the electrometer is zero, for all four quadrants are equally and similarly electrified by it. The inductive action of *a* on *b* is equal and similar to that of *e* on *d*, and, consequently, the effect of *a* and *e* on the electrometer is also zero, and thus, however strongly the plates are electrified, there will be no deflection of the electrometer as long as the arrangement is symmetrical.

Now, however, let the dielectric be introduced between *a* and *b*. By reason of its specific inductive capacity being greater than that of air the action of *a* on *b* which passes through it will be greater than that of *e* on *d*, and, consequently, though all four quadrants are still similarly electrified, the electrification of the shaded quadrants will be strongest, and the needle will be deflected. Let, now, the screw be worked, and plate *a* moved so as to increase the distance *a b*. The action of *a* on *b* will be diminished, and when *a* has been moved so far that the needle has again come to zero, we shall know that the increase of distance which has been made by moving *a* has diminished the induction by an amount exactly equal to the amount by which it was increased by the greater action through the dielectric under examination. Knowing the thickness of the dielectric and the amount which *a* has had to be moved, we can calculate its specific inductive capacity.*

Let us now set the reversing apparatus to work, and suppose the equilibrium not to be established. Suppose that we have inserted our dielectric but have not moved *a*. At first let the direction of the electrification be that of the upper signs, Fig. 22. Then there will be a deflection in a direction opposite to the hands of a watch, that is to the left. Now let the electrification be reversed. If the needle is charged in the ordinary way, and remains positive, there would be a deflection to the right. When the reversals were rapid the alternate impulses to right and left would neutralise each other, and there would be no deflection, however much the equilibrium was disturbed.

To get out of this difficulty a plan was designed which, as it is due to Professor Maxwell and not to myself, I may call beautifully ingenious. Instead of keeping the needle permanently charged it is connected to the centre plate *c* and reverses with it. First, let us suppose the electrification has the upper sign, and that by introducing the dielectric we have made the shaded quadrants the strongest. The force will be attractive, and the needle will turn to the left. On reversing the electrification, so that they are all those of the lower signs, the shaded quadrants will still be the strongest, the force on the needle will still be attractive, and it will still turn to the left.

In practical work, when the electrifications of the five plates, the dielectric, the four quadrants, and the needle are all being reversed 12,000 times per second, the needle is perfectly steady, and so exactly under the control of the screw of *a* that a motion of *a* of 1-1000th of an inch nearer to or further from *b* produces a perfectly visible motion of the light spot which indicates the motions of the needle.

(TO BE CONTINUED.)

* The formula of calculation used is as follows:—Let us write K specific inductive capacity, *b* thickness of dielectric, a_1 reading of plate *a* with only air in the balance, a_2 reading when dielectric is inserted. The action across a dielectric of thickness *b* and specific inductive capacity K is the same as that across a thickness of air $\frac{b}{K}$. Hence, when we introduce the dielectric, we do the same as if we had put in a stratum of air thickness $\frac{b}{K}$, and, at the same time, take away the stratum of air thickness *b*, which is displaced by it. Hence, the insertion of the dielectric is the same as if we had decreased the distance between *a* and *b* by a quantity equal to $b - \frac{b}{K}$. But to produce an equal or opposite electrical effect—*i. e.*, to bring the needle to zero—we increased the distance by an amount $a_2 - a_1$. Hence these two quantities are numerically equal, and we have

$$a_2 - a_1 = b - \frac{b}{K}; \text{ that is, } \frac{K}{b} = \frac{1}{b - (a_2 - a_1)}, \text{ or } K = \frac{b}{b - (a_2 - a_1)}.$$

ELECTRIC LIGHTING.

(CONCLUDED FROM P. 177.)

Report presented by M. Cernesson, in the name of the Third Commission of the Municipal Council of Paris:

It now remains to be considered under what conditions these trials should be made, with reference to the financial benefit of the Ville de Paris. The price of 60 centimes per light and per hour proposed by the Compagnie Générale d'Electricité is extremely high; but although it does not appear to be a remunerative price, it cannot be supposed that the Ville de Paris will consent to pay it.* It, however, appears equitable to offer the Company a price equivalent to the light furnished, based on the standard gas jet as a unit for quantity and price.

Thus, while it is asserted that a Jablochkoff light is equal to 11 gas jets, it appears just to pay eleven times the cost of one gas jet per hour—that is, 11 × .021 = .231 francs; but, taking unforeseen contingencies into consideration, it is thought this price may be somewhat increased—say to 30 centimes per hour. In addition to this concession, instead of the Company undertaking, as in the event of a three years' concession, to establish new lamps, &c., at their own cost, it is proposed that they should be authorised to employ only temporary arrangements, and even, wherever possible, to make use of existing gas lamps and fittings, by adding any appliances that can be fitted without damaging them. It is, understood, however, that they undertake the cost and labour of lighting the gas each day after the candles are ex-

* The net cost of the Jablochkoff light per hour has been ascertained by M. Th. Lévy for the 62 lights in the Avenue de l'Opéra as follows:—

	Fr.
Steam power	3.20
Coal for boilers	6.64
Oil, grease, &c.	1.23
Wages	3.20
Sixty-two candles at 50 centimes each	31.00
	45.27

or, per light per hour $\frac{45.27}{62} = 73$ centimes (or 7½ pence nearly). From this it will be seen that, if, as the Compagnie Générale d'Electricité hope, the horse-power required can be reduced to .33 horse-power per light, instead of 1.25 horse-power, a considerable difference will be possible; thus:

		Fr.
Steam power	$3.20 \times \frac{33}{125} =$	.845
Coal	$6.64 \times \frac{33}{125} =$	1.753
Oil, &c.	$1.23 \times \frac{33}{125} =$	.320
Wages, as before		3.200
Candles, ,,		31.00
		37.118

or, per light and per hour $\frac{37.118}{62} = 60$ centimes (or 6 pence).

It should be borne in mind that, although this is supposed to be the net price, 50 centimes for the candle is obviously excessive. Ten centimes, or 1 penny each, should cover the actual cost easily, and thus the total of 37.12 francs is reduced to 12.32 francs, which give a net cost of 20 centimes (or 2 pence) per light and per hour.

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tinguished, and also that they do the same thing whenever an interruption in the electric light occurs. As regards the clause in the Company's proposition relating to the supply of private customers from the street conductors, the Committee recommend an unconditional refusal, in order to avoid the possibility of future complications. The following are the principal conditions to be followed :—

1. In the Avenue de l'Opéra and the two places at the ends the preservation of the present system of 62 lights, including the double candles in the lamps of the Place de l'Opéra.
2. On the Place de la Bastille the installation of 15 lamps.
3. In the pavilion of the Halles Centrales, which may ultimately be selected, the establishment of five or six lights.

The extra expenditure for the year which will be involved by this arrangement amounts to 34,044.48 francs (£1,361.16), as shown by the table below :—

Comparison of Cost in Lighting by Electricity and Gas.

Places Lighted.	Proposed Electric Lighting. Number of Lights.	Price per Hour.	Cost per Hour.	Normal Gas Lighting. Number of Lights.	Price per Hour.	Cost per Hour.	Excess of Cost.
Avenue de l'Opéra, Place de l'Opéra, and Place du Théâtre Français	62	Fr. .30	Fr. 18.60	344	Fr. .021	Fr. 7.22	
Place de la Bastille	15	.30	4.50	101	.021	2.12	
Total per hour	77	...	23.10	445	...	9.34	
For one year from dusk to midnight, or for a total of 2,073 hours	2,073 × 23.10 = 47,886.30			2,073 × 9.34 = 19,361.02			Fr. 28,524.48 (£1,141)
Halles Centrales pavilion	6	.30	1.80	20	.021	.42	Fr. 5,520 (£220.16)
For one year all the night, or 4,000 hours	4,000 × 1.80 = 7,200			4,000 × .42 = 1,680			
	Total excess.....						F.34,044.48 (£1,361.16)

As for the comparative gas lighting, the Committee recommend, after consulting with the representatives of the Paris Gas Company, the following installations :—

1. Rue de Quatre Septembre—The existing gas standards and lamps, to the number of fifteen, will be utilised, placing on them the large model lamps in store in the Ville de Paris depôts. Each standard will be furnished with a crown of eight burners, consuming 1,400 litres (49.4ft.) of gas per hour.

2. Place du Château d'Eau—There are at present 77 lamps in place. Of these 19 will be utilised by giving each 8 burners, the remaining 58 will have each four burners consuming from 740 to 800 litres (26.1 to 28.2ft.) per hour.

3. In the pavilion of the Halles Centrales there will be 20 brackets with eight burners each.

"As to the price for the excess of gas consumed, the Ville de Paris will not be called upon to pay for this, the price of 15 centimes per cube metre (3s. 6d. per 1,000ft.), which is the contract price between the Ville de Paris and the Gas Company; indeed, the latter appears disposed to recognise the fact that, in entering on a trial of this nature, it should make a concession in the price, and the Committee believe that the Ville de Paris will not be called upon to pay for the excess of gas consumed more than .05 centimes per metre (1s. 2d. per 1,000ft.). On this basis the extra outlay for gas would be 261,747.72 × .05 =13,087.39 francs (£523.10).

"The total supplementary estimate to be provided for in the improved lighting for the city of Paris during 1879 will thus be—

	Fr.	£
1. Excess for electric lighting ...	34,044.48	(1,361.16)
2. ,, gas.....	13,087.39	(523.10)
	47,131.87	(1,885. 6)

"The Committee recommend this expenditure, and that permission for it should be made in the budget for 1879.

(Signed) L. Cernesson."

The second table shows the excess of gas that will be consumed :—

Consumption of Gas, Present and Improved System.

Places Lighted.	Improved Gas Lighting. Number of Jets.	Gas consumed per Hour and per Lamp.	Total Gas consumed.	Actual Gas Light. Number of Jets.	Gas consumed per Hour and per Jet.	Total Gas consumed.	Excess in Consumption. Cubic metres.
Rue du Quatre Septembre	15	cb. mt. 1·400	cb. mt. 21.000	15	cb. mt. .140	cb. mt. 2.106	
Place du Château d'Eau	19 58	1.400 .740	26.600 42.920	77	.140	10.780	
Total per hour	92	...	90.520	92	...	12.886	
Consumption for one year from dusk to midnight—say 2,073 hours	2,073 × 90.520 = 187,647.96			2,073 × 12.880 = 26,700.24			160,947.72 (5,684 thous. c. ft.)
Halles Centrales, one pavilion	20	1.400	28.000	20	.140	2.800	100.800 (3,560 thous. c. ft.)
For one year for 4,000 hours	4,000 × 28 = 112,000c. met.*			4,000 × 2.8 = 11,200c. met.			
	Total.....						261,747.72 (9,244 thous. c. ft.)

* To convert cub. met. into cub. ft., mult. by 35.317.

The following is the official memorandum of the project :—

Memorandum of the Municipal Council.—The Council, after consideration of the memorandum of the Prefect of the Seine of the 26th of November last, relating to the various modifications to be made in public lighting, and the report of the Director of Public Works of Paris, and those of the engineers annexed, and on the report of the Third Commission, resolve as follows :—

Art. 1. The Prefect of the Seine is authorised to arrange with the Société Générale d'Electricité for further experiments in lighting, for the space of one year, dating from the 15th of January, 1879, in the following places :—The Avenue de l'Opéra, Place de l'Opéra, and the Place du Théâtre Français, the Place de la Bastille, a pavilion in the Halles Centrales, which shall be selected by the Administration.

Art. 2. The electric lighting is authorised on the above-mentioned sites on the condition that the Ville de Paris shall not pay more than 30 centimes (3d.) per light per hour.

Art. 3. The Prefect of the Seine is also authorised to arrange with the Paris Gas Company for an improved system of lighting, experimentally for one year, from the 15th of January, 1879, at the following places :—The Rue du Quatre Septembre, the Place du Château d'Eau; one of the pavilions of the Halles Centrales, to be chosen by the Administration.

Art. 4. The improved system of gas lighting is authorised for the above sites, on the condition that the Ville de Paris will not be called upon to pay on the excess of gas consumed over the normal quantity, more than .05 centimes (1s. 2d. per 1,000 c.ft.).

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The sum of 47,131fr. 87c. (£1,885 5s.) to meet these extra expenses will be included in the budget for 1879.

After a long discussion, the Municipal Council, at a meeting on the 14th inst., passed the following resolutions :—

Art. 1. The Prefect of the Seine is authorised to arrange with the Société Générale d'Electricité for a series of experiments for one year, from the 15th of January, 1879, in the place above named.

Art. 2. The electric light is authorised on the above sites, on the condition that the Ville de Paris does not pay more than 30 centimes (3d.) per light per hour, and that the total expense does not exceed 35,000 francs (£1,400).

Art 3. The Prefect of the Seine is authorised to treat with the Parisian Gas Company for lighting by an improved system the various places already named.

The gas company have offered to furnish gratuitously the excess of gas consumed on the normal amount. It will also furnish the necessary apparatus, if the Ville de Paris undertakes to purchase them, in the event of its adopting the improved system.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

The fifteenth ordinary meeting of the shareholders of this Company was held at the City Terminus Hotel, Cannon-street, on Tuesday, the 4th of March, under the presidency of Sir Daniel Gooch, Bart., M.P.

Mr. WILLIAM SHUTER (the secretary) read the notice calling the meeting, and the minutes of the last meetings, which were confirmed and signed by the Chairman.

The CHAIRMAN then said: Gentlemen, the report [which appeared in *The Electrician* of last week] is already in your hands, and I suppose you do not require it to be read [No, no]. That report also, I think, is so full in itself, that it will require very little for me to say to make you acquainted with all that I could tell you if I were to talk for a very long time. You will see by paragraph 3 that we have laid 565 miles of cable for the Western and Brazilian Telegraph Company. The next paragraph, you see, refers to the expedition to try to recover the Atlantic cable last summer, and you are all aware that we were unsuccessful in completing the operation. The cable, as a rule, was very good, but there were in places short lengths, and very short lengths they were, in which the covering was entirely destroyed; and in those bad places the cable broke, and prevented us from lifting it. The Eastern Telegraph Company has had 330 miles of cable laid for their Cyprus and Alexandria line, and we have altogether, in fact, manufactured during the year 2,631 miles of cable. You see by paragraph 5 that the North Woolwich works are now in our hands. It is a very fine property, and we must wait our time to realise the amount of money we have on those works; and you also see by paragraph 6 that we have during the year given up our interest in the Black Sea Telegraph, which has been taken over by the Eastern Telegraph Company. We also in January last renewed our debentures for a period of five years, as you are already aware. I believe all that I need tell you is contained in the report. The work we have in hand is satisfactory, and what we have done during the year has also been done in a satisfactory manner by our staff. The accounts themselves will show you how our figures stand; and I shall be very happy to answer any question any shareholder may put to me with regard to the report or the figures in the accounts. I am sure you will excuse me from trying to make a long speech, for I am not in a condition to do it, but as I have said, I shall be very glad to answer any question. I now move "That the report and accounts of the directors to the 31st of December, 1878, submitted to this meeting be, and the same are hereby, received and adopted, and that a dividend of 36s. per share (in addition to the 12s. per share interest or interim dividend paid to the 30th of June, 1878) be paid upon all the shares of the Company for the year ending the 31st of December, 1878, and that such dividend be paid free of income tax."

Mr. PHILIP RAWSON: I have much pleasure in seconding that.

The CHAIRMAN: Has any shareholder any remark to make? If not, I will put the resolution.

Mr. WILLIAM ABBOTT: You are always so good in inviting the criticism of the shareholders on the report that I think it would be ungracious if I did not make one or two remarks on it. At the same time, although you invite criticism, I think you are the last man in the world to satisfy the shareholders on any question they may ask you [laughter]. However, perhaps you exercise a wise reticence in that matter in withholding information which you think it undesirable to disclose. At the same time I have a duty to perform, as a number of my friends in the country correspond with me, and ask me why I don't ask Sir Daniel Gooch such and such a question about the accounts, and, in fact, "draw him out." My stereotyped answer is, "You had better come up and try and do it yourself," for a more reticent man I don't know. However, one of the questions I have been desired to ask you—I do not expect you will answer it [laughter], but I will put it and discharge my duty—is, the amount of money which Henley's works represent, and also the price at which you take your other securities? Having discharged my duty so far, I leave it to you to answer those questions or not as you may think fit. The only measure I would urge from my own point of view is, seeing that we have plenty of work in hand and that our dividend for next year is assured, that you ought to make a bold effort and place this balance, which has an uncomfortable look in the eyes of hungry shareholders, at once to the reserve fund. You do not require it, and it would bring your reserve fund to £109,000, or nearly 25 per cent. of your entire capital. In a former time of prosperity you saw fit to return £8 to the shareholders out of profits, and I think in the present year you might add that amount to the reserve fund, and have done with it. I am perfectly satisfied with the dividend you have declared. I do not urge the policy of any further disclosures than you have made in the report, but I think that the time has arrived when you might put that £59,000 to the reserve fund, and make a very handsome sum of it.

The CHAIRMAN: Gentlemen, I think you will take it from me—at any rate, it is my opinion that it would not be wise to state our several securities. I can assure you on the part of the Board—and the auditors, if present, will assure you of the same—that not only as to Henley's works, but also with regard to all our securities, we are perfectly safe. But it would not be wise to go into details. You must trust your auditors and us that we are not doing anything wrong. The question of the reserve is simply this—what I have always urged on you—and you have seen, I think, that it has been the policy carried out—is that our success has a great deal depended on our having free control of capital. We have been able to undertake and carry out works in consequence of our having, in addition to our stocks—our works, plant, and machinery—a considerable available floating capital; and if you put this balance in the reserve, the use, I daresay, we should put it to would be to employ it for the purpose of your interests. I do not see what object would be gained except the merely sentimental one which Mr. Abbott indicated. The deed, too, limits the reserve to £50,000, though you could alter that. There would, however, be no object in it. The reserve is used for your interest, and if we had not other money we should use it. I think there would be no object in putting it to the reserve for the purpose of taking it out again. The £50,000 is invested in stocks which are perfectly safe. The advantage to the shareholders in having a large balance has been very great, and one I should advise them to retain.

Mr. EDWARDS expressed his belief that the fact that the Company had stood the crisis of the past five years so well was in consequence of their having these large sums in hand [hear, hear].

Mr. LAURIE asked if the Company had been commissioned to lay the Cape cable.

The CHAIRMAN: You must not ask me for any details about a matter of that kind, but negotiations are in progress as to the Cape cable. What the result may be you will learn later on. At present there is no final agreement settled with regard to that.

The resolution, as above given, was then unanimously passed.

The CHAIRMAN next moved, and Admiral Sir G. H. RICHARDS, C.B., the managing director, seconded the re-election as a director of Sir George Elliot, Bart., M.P. The motion was carried unanimously, as was also a further resolution, on the motion of the CHAIRMAN, seconded by Mr. G. W. CAMPBELL, for the re-election of Mr. P. Rawson.

Mr. FORD then moved and Mr. S. GURNEY seconded the resolution re-electing as auditors Messrs. John Ball and John Gane.—The motion was carried unanimously.

The CHAIRMAN having intimated that that closed the business,

Mr. FORD said: Mr. Chairman, I have very much pleasure in moving a vote of thanks to you for your conduct in the chair to-day, and more especially for your reticence, which, I think, in a company of this kind, is a most valuable qualification [hear, hear, and laughter].

Mr. WILLIAM ABBOTT seconded the motion, which was carried unanimously.

The CHAIRMAN: I am much obliged to you, gentlemen, for your renewed vote of confidence.

The SECRETARY then intimated, with regard to the Second Bonus Trust, that on these certificates, paid as part dividend to such shareholders as were on the register in February, 1875, seven distributions had become payable. Of these there now remains unclaimed in the bankers' hands a balance of nearly £1,000, a great part of which was due on Coupon No. 7. Those who had not received the supplementary sheets of coupons (Nos. 7 to 12) might do so on presentation of original certificates at the office.

The proceedings then terminated.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices March 5.		Business Done Week Ending March 5. Highest.	Lowest.
Anglo-American	58,	¼	59½	58½
Do. "B"	86½,	7	87	86½
Do. "A"	29½,	30½	31	29½
Brazilian	6¾,	¼	6¾	6 13-16
Cuba ex div.	8,	¼	8¼	8¼
Do. Ten per Cent. Preference x d.	15,	¼	—	—
Direct Spanish	1½,	2	—	—
Do. Ten per Cent. Preference	10,	¼	—	—
Direct United States	11¼,	¼	11¼	11¼
Eastern	7½,	¼	7¼	7 5-16
Do. Six per Cent. Debenture	104,	7	—	—
Do. Five per Cent. do.	100,	3	101	100½
Do. Six per Cent. Preference	11½,	¼	11¼	11¼
Eastern Extension	7 5-16,	7-16	7 7-16	7¼
Do. Six per Cent. Debenture	105,	8	—	—
German Union	7½,	8¼	—	—
Globe Telegraph and Trust	4½,	5	5	4 13-16
Do. Six per Cent. Preference	10½,	¼	10¼	10¼
Great Northern	8½,	¼	8 5-16	—
Indo-European	20,	21	—	—
Mediterranean Extension	2¼,	3½	3 1-16	—
Do. Eight per Cent. Preference	9,	¼	—	—
Reuter's	9½,	10½	—	—
Submarine	215,	25	222	221¼
West India and Panama	1¼,	2¼	2 1-16	2
Do. Six per Cent. Preference	8¼,	¼	8 9-16	8¼
Western and Brazilian	4,	¼	4 5-16	4¼
West. Union Seven per Cent. 1st Mort.	114,	18	—	—
Do. Six per Cent. Sterling ...ex div.	100,	2	—	—

TRAFFIC RECEIPTS FOR FEBRUARY, 1879.

Companies.	Feb. 1879.	Feb. 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,900 estd.	2,818	—	18
Direct Spanish Telegraph Company	784	814	—	30
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	22,409	20,716	1,693	—
Eastern Telegraph Company	37,251	41,831	—	4,580
Great Northern Telegraph Company	12,087	—	—	—

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NOTES.

JAPAN.—The Japanese Government has given its adhesion to the International Telegraph Convention.

THE DIRECT UNITED STATES COMPANY.—Notice is given that the third ordinary meeting of this Company will be held at the Cannon-street Hotel, on Friday, March 21st.

INTERNATIONAL TELEGRAPH CONFERENCE.—The date of the meeting of the Congress has been fixed for the 10th of June. This is the first meeting of the Conference in London.

TRANSFERENCE OF IONS.—Mr. Kirmis finds that the quantity of copper transferred from the solution of its sulphate increases as the concentration of the solution diminishes.

CADMIUM.—Mr. E. J. Smith finds that cadmium may be accurately estimated by the electrolytic decomposition of the acetate in aqueous solution. It is necessary to use a current of about two ordinary Bunsen elements, and a solution of concentration about 1 to 50. The decomposition takes to complete from three to four hours.

LAND LINES IN GERMANY.—For the past three years there has been a great diminution in the interruptions upon these lines. According to the statistics, which have been carefully kept, the total number of interruptions in 1876 was 16,162, falling to 8,171 in 1877, and to 6,214 in 1878, whilst the length of wire in use during these years was respectively 140,992, 151,311, and 160,754 kilometres.

THE SAWYER-MAN ELECTRIC LAMP.—Since the first introduction of this lamp several improvements have been made, one of which is in the bearing of the upper carbon holder to allow for expansion, another is in relation to the switch. There is evidently a strong desire to shirk quantitative and economical tests, and we are still unable to state positively, or even to state approximately, the cost of the light obtained with this apparatus.

NICKEL FOR COMPASS NEEDLES.—Four compasses, furnished with these needles, have been placed on Russian cruisers for experiment. The compasses are constructed nearly in the manner which Sir W. Thomson has so long and ably advocated. It is proposed that a French vessel should be supplied with a compass of this kind, in order that exhaustive comparative experiments might be carried out with that and compasses with needles of steel.

TELEGRAPHIC COMMUNICATION WITH THE CAPE.—An interview was held on Friday, March 7, between the Eastern Telegraph Company and the Government with reference to the purchase of the 1,400 miles of cable which was shipped a fortnight ago for Australia, and which was detained in order that the Government might at once have direct communication with the Cape. The Telegraph Company stipulated for a guarantee against accident to the cable, but this the representative of the Government refused. The negotiations were thus broken off, and by this time probably the ship will have sailed, and there will be no chance of getting another cable laid this year.

ELECTRIC LIGHT AT THE BRITISH MUSEUM.—These experiments, successful so far as the light is concerned, have been, for the time, discontinued, with a prospect of resuming them with the commencement of winter. Meanwhile, the officials at the Museum may not think it beneath their dignity to notice the consensus of opinion as to the cost of the Jablochkoff bougie. If we are to have a light at all, questions of economy must be considered as well as the mere fact of obtaining the light. Why is it that, at the Museum, a place so admirably adapted for such experiments, the conclusions of Mr. Schwendler have found no consideration? The cry is, "Divide the light," and this, he shows, is simply the outcome of ignorance. The cry might better be, "Concentrate and reflect."

USE OF SECONDARY BATTERIES AS AN ADJUNCT IN ELECTRIC LIGHTING.—The following is translated from Mr. Edison's French specification:—"In electric lighting it is often useful to employ a secondary current in addition to the main current. The luminous spirals may be inserted in a secondary circuit, containing battery elements (? plates of the same metal connected like the elements of a battery) by means of a lever acted upon by an electro-magnet. When the lever makes a contact, the current of the principal line passes to the electro-magnet and the batteries, but when the contact is broken, a local circuit is established between the spiral and the secondary battery. The discharge of this battery produces the light, and this so rapidly that there is no appreciable interruption."

A NEW METHOD OF PLANTING TELEGRAPH POLES.—"A new method of planting telegraph poles," says the *Scientific American*, "has been introduced in Pennsylvania. The ground is staked off at distances of 200 feet apart; a man starts off with cartridges of 'electric powder,' and with a crowbar in his hand. The bar is driven four or five feet into the ground, a cartridge with a lighted fuse is dropped into the hole, and the man proceeds to the next stake; but before he reaches it the cartridge has exploded, making a cavity as big as a flour barrel in the ground, and a gang of men who follow plant a telegraph pole in the spot. In this way four men will set up 100 to 150 poles per day, and at a cost two-thirds less than by the old way."—We trust the authorities in England will think twice before adopting such an ingenious, but, we fear, totally impracticable plan.

EDISON'S PATENT FOR ELECTRIC LIGHTING. (French Specifications.)—We translate the following observations from an article on this subject in the *Revue Industrielle*:—"We have at length been able to examine the French patent of Mr. Edison, which, far from altering the impression produced upon us by the perusal of the *Scientific American*, has more than ever convinced us that the system of electric lighting of the learned physicist of Menlo Park is very much beneath his reputation, and there is absolutely nothing in the new patent that could justify the panic amongst the holders of gas shares in Europe as in America. It is really an immense and lamentable mystification. Let us at once state, however, that, from a theoretical point of view, the apparatus devised

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by Mr. Edison is far from being absurd; the patent includes some ingenious details and certain arrangements which are sufficiently original; but, from the practical point of view—the only one that could interest gas shareholders—all is mediocre, childish, or impossible of realisation. We should not even have referred to this patent had not the patentee the distinguished merit of having invented the phonograph. It is especially the errors of great inventors that should be exposed, since these are the most dangerous."

THE METROPOLITAN BOARD OF WORKS.—On Friday, March 7th, a report was presented from the Fire Brigade Committee, stating that they have had under consideration the desirability of placing all the fire escape stations and the police fixed points in telegraphic communication with the Fire Brigade stations. They had communicated with the Commissioners of Police of the Metropolis and of the city of London, and ascertained that there would be no objection on their part to such connection being made, and that they would render all the assistance in their power. To carry this out all through the metropolis would, of course, involve considerable expense, and it was desirable that, in the first instance, it should be tried over a limited area. The committee had, accordingly, selected the neighbourhood of each of the four district stations, and had arranged with the Post Office to place each of these stations in communication by telegraph with the fire escape and police fixed points adjacent. The circuit of the Westminster station will connect seven call-points with the station; that of Clerkenwell, ten; that of Whitechapel, five; and that of Kennington, four. These circuits will be maintained by the Post Office for an annual rent of £233 10s., under a lease for seven years, at the end of which time the expense will be somewhat reduced. The report was received and adopted.

A NEW FORM OF CARBON.—In describing the Sawyer-Man electric light last December, mention was made, says the *Scientific American*, of the peculiar carbons employed, the manner of their production being a secret, which Mr. Sawyer did not choose at that time to disclose. We have now been favoured with an exhibition of the process, and a very pretty one it is. The carbons are about half an inch long, with the diameter of one-sixteenth of an inch. Their colour is steel grey, and the surface is hard as steel; within the carbon is tolerably soft. In his earlier experiments, Mr. Sawyer employed, as the source of incandescence, slender pencils of gas retort carbon in an atmosphere of illuminating gas. The carbons were slowly destroyed, but at the same time they took on a superficial deposit, evidently of carbon, but unlike in lustre and hardness any carbon that Mr. Sawyer had seen. Inferring that a more rapid deposit would be made in a denser hydrocarbon, Mr. Sawyer experimented with a great variety of such liquids, finding olive oil most satisfactory. His method is simply to heat the carbon to an extremely high temperature by passing through it an electric current while it is immersed in the oil. The best results are obtained by the use of a pencil of willow charcoal, upon which an intensely hard deposit of carbon rapidly forms as the hydrocarbon is decomposed by the heated pencil.

PHYSIOLOGICAL EFFECTS OF MAGNETISM.—The following is of interest in relation to the numerous "magnetic" appliances advertised as being of wonderful efficacy in the cure of disease:—"As all substances are under the influence of the magnetic force, it might be expected that the vital functions would suffer some modification from the action of magnetism on organised bodies; but hitherto no conclusive and unequivocal evidence on this point has been obtained. Various phenomena have been ascribed to it; but the inconstancy of their occurrence throws great doubt over the opinion that they are really the effects of the magnetic force. The failure of their production in persons on whose statements confidence can be placed, and their occurrence chiefly in females, and in those called nervous, are reasons for suspecting some error or fallacy in the statements of practitioners who advocate the influence of magnetism on the vital functions. Dr. Faraday does not seem to be susceptible of the magnetic force, for some years ago he allowed Dr. Keil to try, in a variety of ways, the influence of powerful magnets on him, but no perceptible effects were produced; and he informs me that he was never sensible of any effect produced on him by the powerful magnets which he used in his recent experimental investigations on magnetism (see Phil. Trans. for 1846), although he purposely submitted various parts of of his body to their influence, and tried in all imaginable ways to obtain some evidence of their effect."—*Pereira's Materia Medica*, Vol. I., pages 59 and 60.

DUFOUR'S RESEARCHES ON THE INTENSITY OF CURRENTS AND OF THE MAGNETISM IN BELL'S TELEPHONES.—The maximum intensity observable is obtained by pressing on the vibrating plate so as to bring it into contact with the soft-iron termination of the magnet. The displacement it thus undergoes is about 1 millim., and produced a deflection of 7–8° upon the galvanometer which I used. An equal deflection in the opposite direction is observed when the plate resumes its initial position. The movement of the plate towards the magnet produced an inverse induced current in the three instruments which I tried, the pole of the magnet being, in fact, behind the coil through which passed the cylinder of soft iron. For the purpose of knowing if the two currents, direct and inverse, possess an appreciable difference of intensity, the wires of the telephone were put into communication with two carbon electrodes dipping in water, and which could be connected with the galvanometer by means of a commutator. A great number of vibrations of the plate were produced, so that a series of induced currents, direct and inverse, traversed the liquid. The electrodes connected with the galvanometer gave no polarisation current. From this we may conclude that the difference of intensity of the two currents is very slight. In the construction of the telephone, therefore, no account is to be taken of the action which this difference may in time exert upon the magnetisation of the bar. Two of the instruments employed had poles of opposite names submitted to the action of the coil; and, when joined, they worked as well as those which are symmetric. The variations of intensity of the magnetism were ascertained in the following manner:—The north pole of the magnet of a Weber's magnetometer was submitted to the simultaneous action of the south pole (surrounded by the coil) of a telephone, A, and the south pole of a magnet. These two instruments were placed so that the bar of the magnetometer was in equilibrium between them. A second telephone, B, was in communication with A. The movements of the mirror of the magnetometer were observed by the ordinary method of reflection of the divisions of a rule in the field of a telescope. A pressure exerted upon the plate of B permitted a slight displacement of the magnet to be ascertained; but the movement was too small to be measured. Its direction was always that which the theory caused to be foreseen.

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FOUR LECTURES ON ELECTROSTATIC INDUCTION.

JAN. 16, 23, 30, AND FEB. 6.

BY J. E. H. GORDON, B.A.

(Assistant Secretary of the British Association).*

LECTURE III. (CONCLUDED FROM PAGE 190.)—JAN. 30.

SPECIFIC INDUCTIVE CAPACITY.

We now turn from the mathematical diagram to the actual instrument. Here you see we are hampered by many troublesome conditions; we have not only to say, "Let *a b c d e* be plates in such a position," but to support them in that position without the supports interfering with their action, not only to say, "Let them be insulated," but to make sure that no electricity escapes, and again we have not only to say, "Let the dielectric be removed and replaced," but to provide means for removing it. You see we must not put our fingers in between the plates when the apparatus is in action.

Well, here is the apparatus (Fig. 23), as it grew up in the course of three or four months' labour. Four of the plates, viz., *b c d e*, are supported from brass stages, carried on brass pillars. Each plate hangs by a thin steel rod, which is rigid enough to move the plate a little out of the vertical, if required for adjustment. The upper end of each steel rod passes through a hole in the stage, and is attached to the centre of a little ebonite triangle, *e*, which rests on the stage by three levelling screws at its angles. By means of these screws the plates can be adjusted to be exactly parallel with each other. When the plates are adjusted, they are clamped by screws, which come down upon the triangles from the stage above. The wires connected to the steel rods lead from each triangle to the binding screws *f f*, by which wires from other instruments can be attached to them.

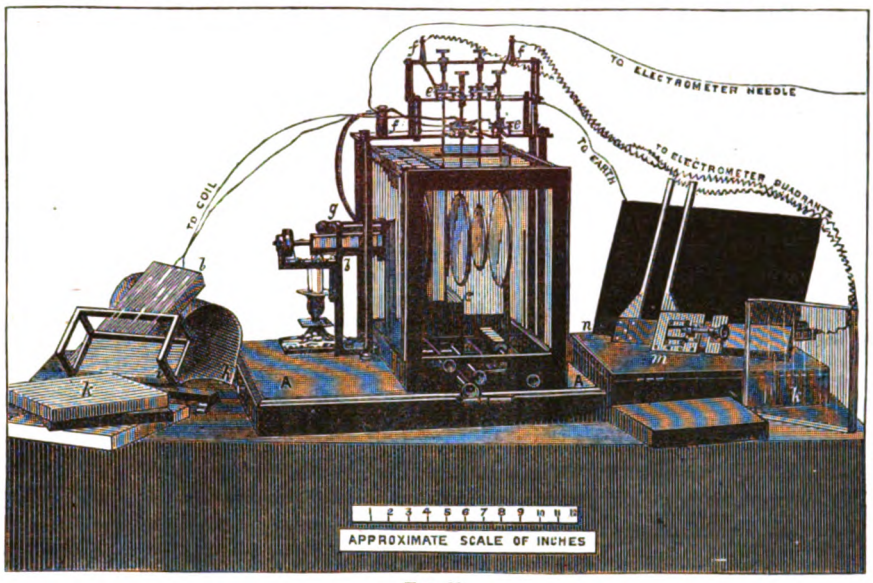

FIG. 23.

The remaining plate, *a*, is supported differently. An ebonite block is fixed at the back of it, and this is fixed to a brass rod, *b*, about an inch thick of the shape ▽ and about six inches long. This slides in two V shaped grooves in two brass pillars *b*, and is pressed down into them by springs. It is moved by a very delicate screw, with a specially contrived spring collar, to avoid "back lash," as it is called, that is to ensure that the motion of the plate reverses at the same instant as the motion of the screw head is reversed. A scale is engraved on the sliding rod, and a vernier on one of the supports. This scale is read to 1-1000th inch by a telescope fixed on the case of the instrument behind *g* (it cannot be seen in the engraving). The scale is illuminated by a candle.

The dielectrics *k k* are made seven inches square, and their thickness varies from ¼ inch to 1 inch.

The slide for inserting and withdrawing the dielectrics is shown, *c d*, in the picture. It moves in guides, and can be pulled in and out by the square handle without opening the case, or disturbing the experiment in any way. The three other handles are for adjusting the position of the dielectric, one moves it parallel to itself by means of a rack, one turns it round a vertical axis by a tangent screw, and the third round a vertical axis by screwing in or withdrawing a wedge under one side.

The callipers *m* shown in the same figure are for measuring the thickness of the dielectrics, and for adjusting the plates parallel to each other. For this latter purpose they are laid on the hinged bracket *n* which can be fixed to a socket at the back of the apparatus.

In work all the upper stage which contains the connections of the plates receiving the induction is enclosed in a metal box connected to earth, the wires leading to the electrometer are enclosed in a metal tube, and the electrometer itself is in a metal case. The reason of this is to protect these parts of the apparatus from accidental induction from the connecting wires, &c. If from any accidental cause the earth connection is interrupted the effect is at once seen in the uncertain and irregular behaviour of the instrument. The metal cover first used for the upper stage is shown. It was made of card and tinfoil. A brass one is, however, now used instead of it.

Before going any further I must express my obligations to Mr. Kieser, of the firm of Elliott Brothers, for the admirable way in which he has constructed the instrument from my drawings. The electrometer is of the ordinary Elliott pattern quadrant described by me in the last lecture in the account of Hopkinson's experiment.

The source of electricity is a large induction coil by Apps, having twenty-two miles of secondary wire (Fig. 24), which, with a suitable battery and break, is capable of giving a seventeen-inch spark in air. In these experiments it is, however, used in a different manner. The object is to obtain a moderate electrification, very rapidly reversed, and to ensure that the positive and negative electrifications should have equal strengths.

When a coil is worked in the ordinary way, although the same quantities of electricity are produced both on making and breaking the primary, yet the arrangement of the currents is such that the current produced in one direction on breaking will produce a much stronger external effect than that produced in the other direction on making. To obtain equal electrifications in the two directions it is necessary to use a very large coil, a very small battery, and a very rapid break. In these experiments the current in the coil primary is only that of ten small Leclanché cells. The rapid break is shown in Fig. 24, and also on a larger scale in Fig. 25. It consists of a little electro-magnetic engine. The scale of inches in Fig. 25 shows the size. One electro-magnet is fixed, and another revolves. A commutator is so arranged that the force between approaching poles is always attractive, and that between poles which are moving apart repulsive. When worked by four quart-sized Grove cells the flywheel of this engine revolves just 100 times per second. You see the whole engine is not more than eight inches long and four high and broad, but when I set it in motion the hum and vibration are felt all over the building. In the rim of the flywheel, which is about two inches diameter, are 60 slits cut, into each of which is let a piece of ebonite. A light spring presses on it, and the primary current on its way from the Leclanché battery to the coil has to pass from the spring to the wheel. It is thus broken 60 times and closed 60 times in each revolution of the wheel. At each break a current is induced in one direction in the secondary, and at each make one is induced in the other direction. Thus there are 120 alternating currents induced every revolution of the engine, or, as the engine turns 100 times per second, 12,000 each second.

The engine does great credit to its maker, Mr. Apps.

To test the equality of the currents in the two directions, the secondary poles were connected to a small vacuum tube. No effect whatever was produced on the light by reversing the primary by means of a commutator between the engine and the Leclanché battery.

One of the secondary poles of the coil is connected to plate *c* of the induction balance and the other to the plates *a* and *e*, and of course the electrifications of every part of the balance and electrometer are reversed with those of the coil poles. The strength of the electrification is such that a spark could be obtained between the coil poles of from 1-25th to 1-50th of an inch; that is, it is about equal to the direct charge of 2,000 silver cells.

In case, however, the sum of the make and break electricities should not be exactly equal, the machine, Fig. 26, was introduced

* Delivered at the Royal Institution 1879.

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for reversing the secondary current about 30 times per second on its way from the coil to the induction balance. It consists of a wire frame, which dips alternately into different mercury cups, and so reverses the current. It is worked from a crank on the axis of

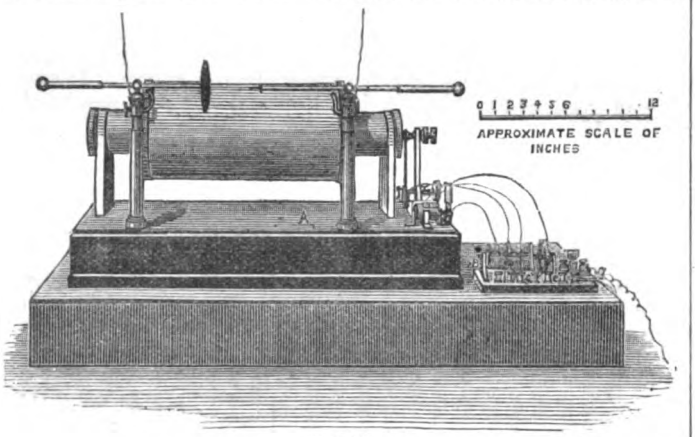

Fig. 24.

a small engine, similar to that of Fig. 26. The speed is regulated by a friction brake, consisting of a silk loop round a pulley on the axle, to which an india rubber band is attached; a cord from this band is wound round a bradawl, driven into the base; by turning the bradawl, the speed can be exactly regulated. This engine is, however, not now used, as the reversals given by the rapid break are, I believe, perfect.

The plan (Fig. 27) shows the arrangement of the apparatus in my laboratory. You see that, standing where I can see the scale, I have the key of the coil primary under my right hand, and the mechanical slide and the screw of a under my left. Compare this diagram with Fig. 22.

Here in the lecture room the apparatus is arranged in nearly the same way, except that, instead of the small scale and paraffin lamp, we have a large scale and lime light, so that you may see the deflections of the electrometer, and that Mr. Cottrell has hinged a long wooden pointer to the induction balance, so that you can all see the motions of plate a.

We will now make an actual experiment on the specific inductive capacity of this beautiful slab of "double extra dense flint" glass.

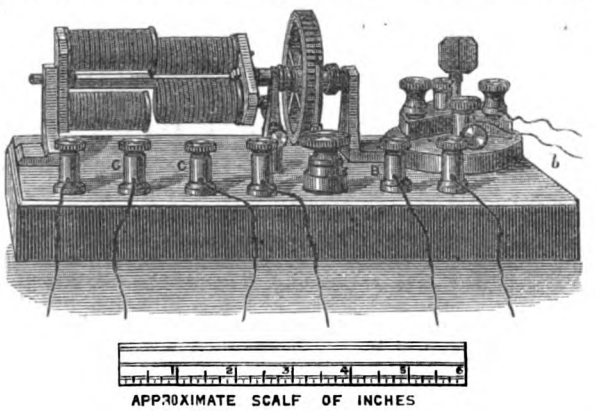

Fig. 25.

I place it on the slide and draw out the latter, so that the glass is not between the plates, and now put plate a into what I think will be about the position of equilibrium. We start the engine and make contact in the primary circuit, and you see there is a small deflection. I move a backward and forward till the light spot comes to zero and remains there as we make and break the primary. We now read the scale of a and write down the result as a_1.

Now I push the handle of the slide and insert the dielectric between a and b. You see that there is at once a large deflection to the left. I work the screw of a and draw it further away from b, and here you see is the light spot coming back to zero, and now, when I have moved a about an inch, I have adjusted the electrometer exactly to zero. We take the reading again and write it down as a_2*. The difference between the two readings is the motion of a, and knowing this and the thickness of the glass, we can calculate its specific inductive capacity by the formula given in the footnote to page 190. On drawing out the glass, there is, of course, a deflection to the right, but you notice it happens from some defect in the adjustment

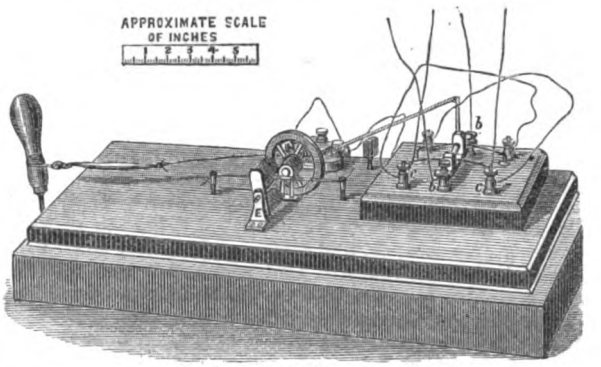

Fig. 26.

of the electrometer that this deflection is very much smaller than was the previous deflection to the left. Here, however, we may see the beauty of the zero method, for we have nothing to do with the magnitude of the deflection, and we see that if we bring the needle back to zero by screwing in a that we require exactly as much inward motion to compensate this small deflection to the right as we previously required outward motion to compensate the large deflection to the left. In fact, when the light spot is again at zero the reading of a is precisely the same as it was at the beginning of the experiment. In actual work successive readings never disagree by more than two, or at most three thousanths of an inch. We cannot, however, get the same accuracy

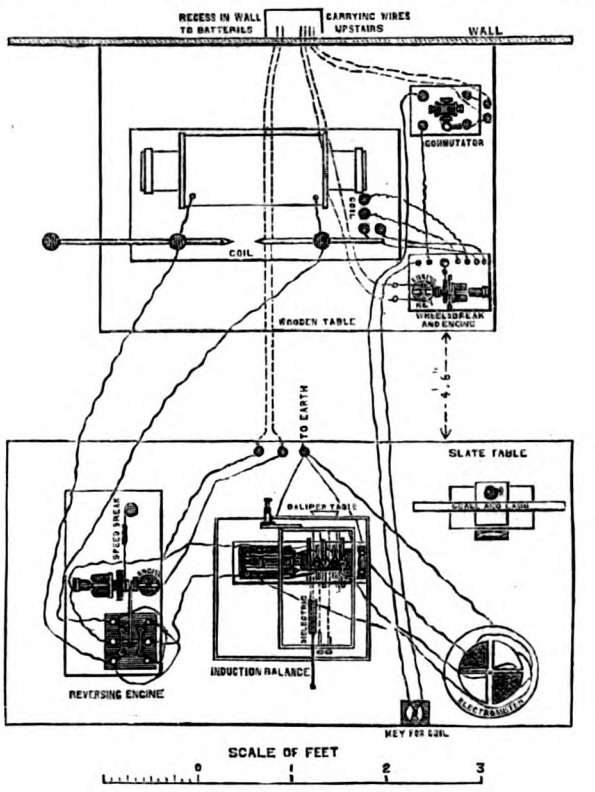

Fig. 27.

here as the rapid break, and the audience are all supported on the same floor as the induction balance and electrometer, and so cause vibrations. In my own laboratory the induction balance and electrometer are supported on brick and slate piers quite independent of the floor on which the break engine and the observer stand. Here on this diagram are the results of my experiments, extracted from my paper which has recently been read before the Royal Society.*

If we look at the experiments on ebonite we shall see that we get substantially the same results with dielectric plates of very different thicknesses. This is a very good test of the accuracy both of the instrument and the formula of calculation.

* In practice the probable position of a_2 is always obtained by a preliminary experiment, and the plate put there before making contact with the dielectric inserted, so that there is never any large deflection. It is found that when large deflections take place the needle does not always return to quite the same zero. In the experiment shown to the audience, however, this was not done in order that the disturbance of equilibrium caused by inserting the dielectric might be more clearly seen.

* Proc. Roy. Soc., 191, 1878, p. 155.

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The experiments on paraffin wax agree very well with each other. The most accurate determinations which have been recently made of specific inductive capacity have been those of Messrs. Gibson and Barclay, who experimented on paraffin only. They used a method entirely different from mine, and found that the specific inductive capacity of their paraffin was 1·977. Correcting for a slight difference of density, I find that if they had used my paraffin their result would have been 1·9833, which differs from my result by only one-half per cent., one part in two hundred.

Dielectric.			Specific Inductive Capacity.
Glass, Slabs about 1 inch thick.			
Chance's optical glass.	Double extra dense flint		3·1639
	Extra dense flint		3·0536
	Light flint		3·0129
	Hard crown		3·1079
Common plate, 2 slabs.	No. 1	3·2581	3·2431
	No. 2	3·2282	
Ebonite, 4 slabs, ¼, ¼, ¼, ¼ inch.	No. 1	2·2697	2·2838
	No. 2	2·2482	
	No. 3	2·3097	
	No. 4	2·3077	
Best quality gutta percha			2·4625
Chatterton's compound			2·5474
India-rubber	black		2·2200
	vulcanised		2·4969
Solid paraffin, sp. gr. at 11°C. 9109. Melting point 68° C. 6 slabs cut in planing machine. Results corrected for cavities.	No. 1	1·9940	Mean 1·9936
	No. 2	1·9784	
	No. 3	1·9969	
	No. 4	2·0126	
	No. 5	1·9654	
	No. 6	2·0143	
Shellac			2·7464
Sulphur			2·5793
Bisulphide of carbon			1·8096†

LITERATURE.

THE TELEGRAPH IN AMERICA.

The Telegraph in America: its Founders, Promoters, and Noted Men. By James D. Reid. [Derby Brothers, New York.]

FIRST NOTICE.

It is impossible within the limits of an ordinary notice to do justice to an extraordinary book, whether that book be remarkable for its size or its contents. How much more impossible, then, is it to do this when both size and contents are exceptional. The work before us must be placed in the category of those with size and contents exceptional. So far as possible, we shall make these eight hundred and forty-six closely-printed pages speak for themselves, and trust we shall by such a course give our readers a true and just idea of the labour and talents of the author and the value of the work he has given to the world. The occasion of the book is thus described in the preface:—"On the 10th of June, 1871, the telegraphic staff of the American Continent inaugurated the erection of a statue in Central Park, New York, in honour of Professor Samuel Finley Breese Morse, the inventor of the electro-magnetic telegraph. On the evening of the same day, in the same city, a public reception was given to him in the Academy of Music. . . . On the completion of the ceremonies connected with these demonstrations, a pledge was exacted of me as having been an active labourer therein, that they should be appropriately commemorated by a suitable record." The volume before us is the record. The first three chapters sketch that portion of the subject prior to the appearance of Morse, and in a brief manner depict the state of telegraphic science when the Professor entered on his labours. Signal telegraphs are shortly described, first by fires, then, coming to the work of the brothers Chappè, which caused such a revolution in the art of signalling at the end of last and the beginning of this century. The improvements from various quarters are cursorily dismissed, and it is somewhat startling to think that telegraphic communication has been degraded by civilisation, at least, so we must think when we read that "The earliest system of telegraphy for signalling over long distances is said to have originated among the African negroes. The means used were telephonic, and the signals were read by sound, and not by the eye, as in the case of the semaphore, or other early signalling devices." This seems, however, to have consisted of the use of a variation of sound upon a musical or unmusical instrument.

Passing onwards our author notices the work of Dr. Gilbert, Boyle, Otto Guericke, Newton, and others in the 17th Century. Stephen Gray is termed a man of "clear head and of indomitable perseverance." He makes various discoveries, and extends the knowledge of electrical matters, he proves that the human body and its fluids are conductors, he shows that electricity is not proportional to the mass of a body but to the extent of surface, he discovers the insulating properties of silk, resin, hair, &c., and lastly observes the fact of induction. Gray was followed by Du Fay "with a mind of greater analytic power and sagacity." Then Muschenbroek discovers the properties of the Leyden jar, the honour of which, however, must be divided with Von Kleist and Cuneus. Other experimenters follow, and Dr. Watson "in 1747 succeeded in conveying the electric charge across the river Thames." In America the name of Franklin stands prominent, he criticised Du Fay, and put forth a theory of his own. He showed the similarity between electricity and lightning, he made the first lightning rod, and transmitted in 1748 "the electric spark across the Schuylkill river, near Philadelphia." In 1810 Dr. J. Redman Coxe, of Philadelphia, "proposed a signal telegraph, using the current of the recently-discovered pile to produce electrical decompositions at the end of wire conductors, evolving visible gas as signals of letters, and for which he employed thirty-six wires." In Europe the discoveries of Volta in 1800, of Schweigger in 1828 are noticed, as are those of H. Gray Dyer, and Professor Henry in America. This brings us to the portion of the book dealing specially with the life and labour of Professor Morse, which we shall notice in a future number.

† I am not quite certain of the accuracy of this result.

THE DIRECT UNITED STATES CABLE COMPANY

Abstract of the Report to be presented at the third ordinary general meeting of the Company, on Friday, March 21:—The Directors submit with this report the usual statements of account for the half year ending 31st December, 1878. The revenue for the half year, after deducting out-payments, amounted to £89.943 14s. 8d. For the corresponding half year of 1877, the amount of revenue, after similar deductions, was £84,217 12s. 10d. The working and other expenses, interest on debentures of the old Company and income-tax amount to £21,743 9s. 11d., leaving a balance of £68,195 4s. 9d. as the net profit for the half year, making, with £2.933 3s. 7d. brought forward from the previous half year, a total of £71,128 8s. 4d. In the corresponding half year of 1877 the expenses and payments above mentioned, and cost of repair incurred during that period, amounted to £25,046 2s. 10d. Interim dividends of 1½ per cent. each for the quarters ending 30th September and 31st December, 1878, together amounting to £30.355, have been declared and paid. A sum of £32,500 has been added to the reserve fund (thereby increasing it to £73.139 14s. 9d.), and a further sum of £3,000 has been written off the preliminary expenses, leaving a balance of £5,273 8s. 4d., which has been carried forward. The necessary six months' notice was given in July last of the intention to pay off the debentures of the old Company, and the amount and interest have since been paid. It was deemed expedient that a member of the Board should proceed to the United States and Canada with reference to questions which had arisen upon the reconstruction of the Company, to complete the necessary arrangements with associated companies, and generally to investigate the working of the Company's system on the western side. Accordingly, during the autumn of last year Captain Mayne visited the Dominion and the United States. The agreements between the Atlantic and Pacific Telegraph Company and the old Company, and between that Company and the Franklin Company, have been adopted with some modifications, and an agreement to carry out the negotiations with the Dominion Telegraph Company of Canada, referred to in the report presented to the members at the last half-yearly meeting, is now under consideration by that Company. The arbitration proceedings between the liquidators of the old Company and Mr. Loeffler, one of the dissentient members, have extended over a period of ten months, and occasioned considerable labour to your Directors and the staff. It is with much satisfaction the Directors state that the proceedings were closed on the 5th February last, and they now await the arbitrator's award. The Muirhead duplex system has been applied to the main cable. An interruption of the main cable occurred on the 4th January last. The break has been located at about six knots from the Torbay station. An interruption also occurred in the short cable on the 12th February. This break has been located on Brown's Bank, about 290 knots from Rye Beach. Both breaks are in shallow water, and, with favourable weather, the repairs will be speedily effected. Owing to the operation of the agreement with the Anglo Company, the receipts of this Company are not affected.

ELECTRIC LIGHTING.—The chairman of Ways and Means proposes that the select committee on the Liverpool Lighting Bill shall consist of Lord Lindsay, Mr. Adam, Sir Ughtred Kay-Shuttleworth, and Mr. Spencer Stanhope. Three members are also to be appointed by the committee of selection, and the committee of seven thus constituted will inquire, having reference in particular to the Liverpool Lighting Bill, but generally also in contemplation of all the private Bills of the Session, asking for powers of the same nature, "whether it is desirable to authorise any schemes for lighting by electricity or other improved methods," and "how far and under what conditions, if at all, the use of such modes of lighting should be sanctioned by Parliament in the case of municipal corporations, other local authorities, or public companies."

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

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NOTICE TO EDITORS.

We shall be happy to exchange with the Editors of Scientific journals who receive the first numbers of THE ELECTRICIAN.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

I Signori Editori di giornali scientifici che riceveranno i primi numeri dell' ELECTRICIAN *ci faranno cosa gradita accettando il cambio che loro offriamo.*

VOL. I. of THE ELECTRICIAN,

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TELEGRAPHIC COMMUNICATION WITH THE CAPE.

In previous articles dealing with this subject we have expressed an opinion that the Government, being fully cognisant of the value of telegraphic communication with the Cape, would not hesitate to aid in making such connection. The deputation that waited upon Sir Michael Hicks-Beach on Feb. 21st mentioned that some fourteen hundred miles of cable was at that moment ready, on certain conditions, to be transported to the coast of Africa, and laid, in connection with the Eastern Company's system, from Aden. We have no doubt that, had the Government seen as other people see, this length of cable would have been at least ten days ago on the road to Aden, preparatory to the commencement of the operation of laying. On Friday, the 28th of February, an interview between the Eastern Telegraph Company and the Government was held, in reference to this length of cable which is on board ship and in readiness to proceed. We may say that the cable has been manufactured for the purpose of duplicating the Australian line, but in such an emergency as the present it could be used for another position. The exact terms offered to the Government are not, of course, public, but we have every reason to believe that they were exceptionally advantageous. A guaranteed subsidy was required for a certain number of years on condition that the cable was kept in working order. This subsidy would lapse were these conditions not fulfilled. We were considerably astonished to find the reply to the deputation just the opposite to favourable. Negotiations were broken off, and in all probability before these lines are published the cable will have started on its voyage to its original destination.

As Carlyle says, "If aught in the history of the world's blindness could surprise us, here might we indeed pause and wonder." If we pause to think of the facts, to realise the jeopardy in which the remainder of Lord Chelmsford's column and the colony of Natal were for a time placed, we cannot but wonder at the reasoning which causes the ready means of communication to be coolly put aside. Is the danger in Natal over? Is the Cape itself free from alarm? Is the space of three weeks unimportant in such a crisis? Is it absolutely certain that the troops now sent are going to victory? Is there any chance of the repetition of the disaster at Isandula? Such questions as these, if calmly considered, must result in coming to the conclusion that an immediate means of communication is an imperative want, and yet the very thing which everybody sees is demanded is the very thing the Government calmly decide to consider at a more convenient season. This article will probably be published on the 15th of March, and it is hardly too much to say that had the Government decided on the 21st February to accept the favourable conditions offered the cable would have been completed to Zanzibar by the 15th of April; in other words, we should probably have heard from this new source of communication of the arrival of the last contingent of the reinforcements sent to Natal. It seems to us that about this time (15th April) the campaign will be recommenced, and the necessity for constant communication with the home authorities will be as great as it is now, and yet by the wilful act of the Government two or three weeks must elapse before we know of what is taking place. Putting aside all questions of commercial importance which, in the long run, are of the most weight, we would urge that, considering the exceptional circumstances of the case, the Government should lose no time in repairing the error it has committed. Probably the vessels bearing the cable will sail through the Suez Canal, and as far as Aden telegraphic instructions can be sent to stop the cable and order its being laid from Aden along the African coast. It may be urged that we lay too great a stress upon the value of this fourteen hundred miles of cable. Not so. It is doubtful whether if the existence of Natal, Cape Colony, and the whole of the English possessions in Africa depended upon it, a cable could be laid to the Cape this year if the length we have mentioned is allowed to go elsewhere. The construction of three or four thousand miles of cable is no light task, and the number of manufacturers is limited—in fact, nine out of every ten miles of cable made for deep sea purposes are made by the Construction and Maintenance Company. This company has facilities which are not to be found elsewhere in the world, and yet with its capacity of construc-

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tion strained to the utmost the time which must elapse would probably see the end of the Zulu war, unless, indeed, as the Rev. Otto Witt says, the war must of necessity be one of extermination. At any rate, the political horizon of South Africa is so overcast that for many months—perhaps, years—to come a peaceful settlement seems out of the question, and the cost of the subsidy demanded for laying the cable would be repaid over and over again before the end of this year.

CORRESPONDENCE.

"POTENTIAL," *CUM ALIIS REBUS.*

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In a recent lecture before the Liberal Social Union, Mr. A. Hope Moncrieff amused his audience by an anecdote anent a church dignitary whose interpretation of a scriptural passage had been controverted by well-known critic. Addressing his congregation, the former observed:—"My brethren, there may be some little difficulty about this interpretation—we must admit that there *is* a difficulty; but what we have to do is to LOOK IT STRAIGHT IN THE FACE, *and pass on!*"

Now, Sir, in regard to the circumstance pointed out by me that electromotive force has, since the time of Georges-Simon Ohm, been defined as difference of tensions, whereas it is now referred to as "difference of potentials," I do not know whether Dr. Lodge has looked this difficulty *straight in the face;* but he has certainly *passed on.* Accepting this gentleman, for whose mathematical acquirements I have a great respect, as a representative of what I may term, for the sake of distinction, "the scholastic system of electricity"—in which, according to my view, physical causation is entirely lost sight of amidst mathematical devices and artificial methods—I intend, with your permission, fully to answer his statements, inferences, and invitation, from the standpoint of what I may call the "physical system of electricity"—that which is, to a great extent, as yet *scientia non scripta,* and which is mainly the outcome of constant experimental observations and practical engineering methods. But for the present I will confine myself to the question immediately at issue—that relating to the use of the word "potential," where "tension" was formerly employed; as, for instance in the above expression "difference of potentials," or in the statement that "the potential at any point of a charged telegraph conductor varies directly as the distance of the point from the earth contact." Of course, if a person using the term "potential" really means the sum of the series $\frac{q}{r} + \frac{q_1}{r_1} + \frac{q_2}{r_2}$, &c., or $\Sigma \frac{q}{r}$, or refers to the work done in bringing a unit of positive electricity from infinity to a point, or *vice versâ*, such use of the term is liable only to the objection that mathematicians are by no means agreed as to its exact definition, as is sufficiently evident from Dr Lodge's last letter. But when electricians who would be disinclined to hazard any definition of "potential," and still more disinclined to illustrate a definition, constantly use this term in the exact sense of "tension" as defined and illustrated in the text-books whence they derived their electrical knowledge, they may, as your contemporary *l'Electricité* observes, be compared to that character of Molière who, being unacquainted with Greek, nevertheless delighted in impressing others in the same position with his proficiency in that language.

Dr. Lodge "ventures to think" that this "is not really an open question." But, without encumbering your pages with a list of all the authorities who use the expressions "tension (or potential)" as synonymous, I submit that until the following statement by an electrician who, though he does not profess to be a mathematician, has a very intimate knowledge of electrical physics, is modified or withdrawn, the opinion of Dr. Lodge is far from decisive in this matter. In his "Elementary Treatise on Electrical Measurement" Mr. Latimer Clark says:—"We will now treat of electrical *tension* or *potential*. The two terms are perfectly synonymous, but the word potential is generally preferred by mathematical writers." The whole chapter on "Electrical Tension" in the treatise mentioned is well worthy of perusal in relation to the present subject.

Dr. Lodge complacently regards his system as the representative of advanced ideas in electricity; and he speaks of the "fog in which the old-fashioned terms and methods must inevitably leave" my pupils and many others. Now, I conscientiously believe that Dr. Lodge is labouring under a misconception in regard to both of these points. Many of my pupils, engaged in practical work at submarine telegraph stations and elsewhere, are in a position to speak for themselves, and those who had received any scholastic tuition in electricity know that their chief difficulty was to *unlearn* everything they had learned. Certainly, some of them would now smile if told that "the capacity of a sphere *in space* is simply the radius," or that one of the insulated plates of a condenser has a capacity "in space by itself," or that the tension (or potential) of a charge is greater at pointed than at rounded or flattened portions of a conductor, or if asked to calculate the potential energy of unit positive electricity placed at a point. But in regard to the general intelligent comprehension of electrical principles, I think they would compare favourably with the pupils or graduates of any "centre of learning," where unit capacity could be defined as "the capacity of an isolated sphere of unit radius,"* or where the inducteous charge from a polarised conductor when connected "to earth" (in Great Britain) could be described as passing to the "whole earth," and getting "safely out of our way somewhere in Australia."†. For my own part, I venture to think that the whole of the "scholastic theory of electricity," including the law of electrical attraction according to the inverse squares of the distances (which is a conditional "law of phenomena," and not a fundamental law), requires only a good push to send it toppling over on to the ruins of former theories of "dissimilated electricity," determinations of the "velocity of electricity," and more recent hypotheses of "electricity as a mode of energy." And I think, moreover, that there are several amongst our known electricians who could administer this push, and who *would* do so were it not that they doubt their ability to reconstruct when the work of demolition may be effected. For, in truth, we have none of us any reason for self-gratulation when we come to consider the physical accuracy of the theory that can be built with the materials which have been supplied to us by mathematicians, albeit such theory may be a more or less perfect substitute for actual fact. Some amongst those who understand the correct definition and measurement of "force" have for some time past commenced to realise with some consternation that there is in nature no *force* corresponding to and varying as "electromotive force," or as Q R; and that there is in nature no *resistance* varying as "conductive resistance," or as $\frac{E}{I}$. And, outside of those to whom, as mathematicians, the real nature of electricity or of electrical force is a matter of indifference, there is, consequently, but little disposition to regard with complacency the progress we have made in electrical theory.

With your permission I will in a future communication consider the "Articles of Faith" attributed to me by Dr. Lodge.—Yours, &c.,

DESMOND G. FITZGERALD.

POTENTIAL AND TENSION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps the following remarks on this subject may be acceptable, viz.:—

A galvanic cell may be said to have an *electromotive force* E, and, when the circuit is open, the *tension* T at the pole is equivalent to E. Now, suppose a ball of unit surface at tension zero connected by a wire with the pole, current will flow, and the tension will vary from the ball to the pole. E remains constant. After the consumption of, say, unit zinc, the ball will be charged with, say, unit quantity of electricity, and be at, say, unit tension. Let us now remove the conductor, and consider the ball alone. It will exert an influence in the space around, and work will have to be done or received by a body moving in its neighbourhood. A concentric circle to the ball is an *equipotential* line, and no work will be performed by moving the body in that line; but if the body travels towards the ball, it will pass by points of different *potential*, and work will be done. Thus the potential of a point does not necessarily involve either the presence of a body or any quantity of electricity at that point. This cannot be said of tension.—Yours, &c.,

C. A. FAURE.

March 8, 1879.

GAS v. ELECTRIC LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the comparative cost of the electric light and gas for the illumination of Waterloo-place, Regent-street.

According to the *Engineer* of Feb. 7th, 1879, the total light of

* *Vide* Exercises in Electrical and Magnetic Measurement. By R. E. Day, M.A., pp. IX.

† *Vide* Lecture, at the Royal Institution, "on Electrostatic Induction." By J. E. H. Gordon, B.A. *The Electrician*, Feb. 22, p. 159.

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the gas from the new burners is 3,680 candles, and the cost is stated by that journal to be 3s. 6½d. per hour.

The gas lamps now in use could be replaced with great advantage by five electric lights, each worked from one of the A Gramme machines, the hourly cost for which need not exceed 3s. (an hour), including all working expenses of the steam engine, carbons, and two attendants.

The amount of light given by the five electric lights would be about six times that given by the present gas arrangements.—Yours, &c., M. RADCLIFFE WARD.

British Electric Light Company (Limited),
41 and 42, Parliament-street, S.W., March 4, 1879.

IRIDIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Replying to the query in the "Notes" of your issue of March 1st, with reference to Mr. Children's experiments, I would mention that Mr. J. G. Children contributed several papers to the *Phil. Trans.* between the years 1809 and 1815, principally upon the subject of experiments with large voltaic and galvanic batteries.—Yours, &c., ALFRED J. FROST.

March 6, 1879.

MR. CHILDREN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* of March 1st I see the questions, "Who was Mr. Children?" and "Where were his experiments recorded?"

Mr. Children was the intimate friend of Davy and Wollaston, who valued him much.

The experiments in question are recorded in the *Philosophical Transactions*, 1815.

These experiments were made with a battery of twenty cells, the acting surface of each zinc being fifteen square feet.

While going back to those apparently almost forgotten times, some of your readers may be interested to know that, while acting as an amateur assistant to Davy in a course of lectures which he gave in the Royal Dublin Society in 1809, I had an opportunity of examining the voltaic arc produced by a battery of a thousand pairs of 4-inch plates. It was three inches long, and I was surprised to observe, when screening the eye from the direct light of the arc, a cone of yellow flame visible over it.

I supposed at the time that it was due to the air heated to be luminous.—Yours, &c., R.

THE ELECTRIC LIGHT.

BY MR. LATIMER CLARK.

On the 5th March Mr. Latimer Clark delivered a popular lecture on the above subject at the Eyre Arms, in aid of the funds of St. Saviour's Church.

[We are unable to do more than indicate the heads of the various subjects touched upon in this admirable lecture. It is due also to the author that we should say that the experiments were very numerous and brilliant, the hall being successively lighted up by different systems of the electric light.—ED. E.]

The lecturer commenced by acknowledging the help he had received in various directions in obtaining apparatus and information required for the purposes of the lecture.

Electricity and magnetism are known by their effects, by what they have done for us, although at present it is impossible for anyone to say absolutely what electricity is. We have then to deal with the phenomena due to electricity, and not with electricity itself. These phenomena are seen in the mariner's compass, enabling the sailor to steer his course with exactness through seas and oceans, when the beacon lights in the heavens may be hid from his eyes; in the electric telegraph, the telephone and microphone, in the application of electricity to chemical discovery, and to a daily increasing extent in our manufactures.

Electricity is only now in its infancy, its greatest applications have yet to come, and though we may have taken a very fair bite at our cherry, the greater portion is yet for the future. The greatest discovery looming in the immediate future is the discovery of the mysterious link which binds all the imponderable elements together. Heat, light, electricity, magnetism, physical force or power, what are they, and how are they connected? Mutually convertible, we can from heat obtain electricity, and, *vice versâ* (this was shown experimentally), we can boil water and obtain steam; we can enclose an electro-magnetic engine in an air-tight globe, and thence obtain a perpetual fountain of force, heat, and light. The quantity of electricity, as shown by a galvanometer, is not reduced at the opposite sides of the globe; the only loss is that of tension, resembling lightning on the one side, full of vigour and power; while on the opposite side vigour gives place to listlessness and dulness. So with steam, it enters an engine at 60lbs. pressure, ready to do work, the same quantity coming out at a lower pressure, with barely enough strength to carry itself away. As the tension of the electric current falls, and wherever it falls it is converted into heat, so, as the tension or pressure of steam falls it is likewise converted into heat. It is not unreasonable to conceive that electricity may in the near or far off future take the place of steam.

The electrical manifestation we have to deal with to night is that of light. Whenever, as has been previously said, electricity loses its tension, heat is manifested, and this occurs whenever it moves and meets resistance. Various experiments were shown in demonstration of this. Thus, by means of a chain of metal, alternate links of platinum and silver, light by means of incandescence was shown. With two pieces of carbon the light of the voltaic arc was shown and projected on the screen. The light by incandescence was discovered soon after the invention of the galvanic battery, and is the basis of the Edison, Regnier, and Werdermann lights. The discovery of the arc by Davy was alluded to, and it was pointed out that the fall of tension with the arc is greater than in incandescent lamps, and, therefore, with it the heat and light are greater. This forms the basis of many of the best known lamps, such as the Jablochkoff, Lontin, Rapieff, Siemens, Wilde, &c. These, then, constitute the two classes of lamps:—A. Incandescent, with points in contact. B. Those employing the arc, that is, with a space between the points.

The lecturer stated that he had no intention of describing, or even alluding to all lamps; his desire was to make his audience acquainted with the broad outlines of the subject. The Werdermann lamp was briefly described, and then the hall was lighted by its means. It was pointed out that this lamp requires very low tension, the current can, therefore, be divided in two ways, either for quantity or tension.

The light is perfectly silent and steady, but not powerful, equal to from 50 to 100 candles, and is projected downwards. The Regnier lamp was shown and described. With regard to the Edison light little could be said, as it was not yet entirely known. The first and great patent has caused some disappointment among electricians, though received perhaps with other feelings by gas shareholders. The great principle in it was the regulation of individual lights by the expansion of hot plantinum, but in this he was forestalled by Siemens and Lontin. The Lontin lamp was now shown. The use of incandescent wire to obtain the light was obvious, and very old. It was patented as long ago as 1845 by King for the inventor, J. W. Starr of Cincinnati. Mr. Peabody found the capital required to carry out the experiments, and a cluster of 26 lights each, enclosed in a glass globe, was exhibited to Faraday, whose admiration it excited. The inventor went home after this successful experiment, but did not appear next morning at breakfast. Success had proved too great, and the excitement had caused his death. In 1855 M. de Changy of Brussels exhibited a similar light which brought forth enthusiastic descriptions.

Incandescence of metals, however, is a most wasteful process, Prof. Tyndall has shown that of those rays of heat and light which emanate from the metal nearly 95 per cent. are the dark heat rays, and only 5 per cent. are rays of light. The higher the temperature the greater is the proportion of light rays. All substances become visibly hot at about 1,000°F., at 2,000°F. they become bright red, at 4,000°F. intensely brilliant, the light increasing faster than the heat.

A brief description was given of lamps with the arc, and the Werdermann light gave place to the Serrin lamp. The Wilde lamp was also used to illumine the room. The Jablochkoff light is the one best known, but it is not economical. According to the report of the Commission appointed by the Municipal Council of Paris the cost of the Jablochkoff light is about six times that of gas, even when used till midnight only. Taking into consideration equal illuminating power, the light is estimated to cost about 2½ times that of gas. This system on the Holborn Viaduct was stated to cost 7¼ times as much as gas, but that it gave 7 times as much light, although the light was not so equally distributed. This relative cost only applies to small lights of 200 or 300 candle power. Some authorities admit that with lights of 5,000 candles and upwards electricity is vastly cheaper than gas.

The machines used for generating the current were next referred to, and experimental illustration of their action shown. [As we have, from time to time, discussed and illustrated the most important of these machines it is not necessary to refer again to them here.]

The history of the steps by which these results are obtained is

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interesting. Electrical phenomena were known to the ancients. Job 4,000 years ago says, "Canst thou send lightnings that they may go, and say unto thee, here we are," chap. 38. The old Greek writers mention Amber, and the loadstone was well known in ancient times. In 1269 the mariner's compass, the grandest of all discoveries, had its birth. We can but mention the names of the more modern workers in this great field. Gilbert made himself famous in 1600, Stephen Gray from 1720 to 1736, Desagulier 1742. The Leyden jar was discovered in 1744. In 1753 C. M. Marshall made the first electric telegraph.* The end of the eighteenth century gave birth to the galvanic battery, and then began the wondrous discoveries that followed in its wake. In 1802 Sir H. Davy experimented with 3,000 cells. Sir Francis Ronalds wrote in 1816. Œrsted, in 1819, discovered, and in 1820 published, his discovery which has led to our telegraph instruments. In 1831 Faraday was experimenting on inductive currents, and hardly had he made his discoveries known when they were applied to the construction of machines by Pixii, Clarke, Saxton, and others. In 1841 De Moleyns took the first patent for the electric light, to be followed by Starr and King, and then a number of others. Professor Nollet in 1849 constructed machines. Holmes in 1859 made his improvements, and lighted up Dungeness Lighthouse in 1862, some sixty years after Davy. Wilde in 1863 increased the power of the machine by making the current of one machine pass through the coils of another. In 1866 Alfred Varley patented, and in 1877 Siemens and Wheatstone described publicly, the idea of making the current magnetise its own magnets. This seems to have been previously thought of by Hjorth in 1854. The history is thus brought down to the present day, in which the poorest among us has at command powers which kings in former ages could not dream of.

We have seen that small lights cannot at present compete with gas in price; in fact, these smaller lights as hitherto produced are not much cheaper than large ones, though we may expect great advances in this respect. There is another side to the question. Large lights (5,000-candle to 15,000-candle) produce light much more cheaply than gas.

Mr. Douglas, of Trinity House, says in lighthouse work a pound of coal produces nearly 20 times as much light as if distilled into gas.

Mr. Schwendler, of the India Office, reports that large lights can be produced 50 times cheaper than gas.

Professor Anthony has shown that petroleum or paraffin oil in an engine gives three times as much light as if burned in lamps.

Mr. Deacon, engineer to the Corporation of Liverpool, gives the cost at half to one-fifth that of gas. All other authorities agree on this point.

Here, then, lies the field for the immediate future. The sphere of gas and electricity lie at present quite apart. Gas will always maintain its place in houses, passages, shops, bed-rooms, and small spaces, unless where extra illumination is desired. It requires no steam engine or attendance, no daily adjustment of the carbons; it is not liable to go out. Moreover, the late scare of the gas companies will do good, and lead to much improvement in street lighting.

The brilliant display in Waterloo-place and Waterloo-road can hardly be expected to be maintained. Gas companies need not fear competition. Ninety-five per cent. of their revenue is derived from private consumption and the sale of waste products, and only about 5 per cent from street lighting, which is the worst paying part. The improvement that will be demanded in future will tend to increase their consumption, and gas engines form one of the best sources of power for the electric light. It was ridiculous to see their capital depreciated 15 or 20 per cent. in a fortnight at the appearance of a few newspaper paragraphs by anonymous writers in America. The scare of 1849 was forgotten, and it is curious that electrical engineers, who are all of one opinion, were never consulted on the subject.

On the other hand, electricity has taken its place definitely and firmly, and will continue to extend and be improved. It is already used very extensively and successfully. It gives off no smell. It does not vitiate the air, nor make it unhealthy; it gives a most magnificent light, without sensibly heating apartments; it shows all the most delicate colours; it does not injure furniture or paintings. There is not the slightest danger of fire or explosion, and, lastly, it is, under certain circumstances, the cheapest light known, every horse-power produced by the combustion of two or three pounds of coal giving the light of a thousand candles. All these facts point to a magnificent future.

How astonishing, then, are the wonders of electricity. How fortunate are we of this generation in being permitted to live in a period of such progress. Compare the world of to-day with what it was when many in this room were born—no gas, no steam engines, no electric telegraphs, no photography, no railroads, no steamboats, no telephones or microphones. How proud ought we to feel, too, that our own little island has been the birthplace of most of these wondrous discoveries which have so changed the face of the world. Science has, doubtless, great triumphs in store for us, but just as no previous generation has witnessed such advances as ours, so it is not conceivable that any future generation can see such stupendous changes as we have witnessed. The sceptre of the world has departed successively from India, from Egypt, from Athens, and from Rome, ever travelling westward, and it may one day depart from Britain to travel still further towards the setting sun. But wherever it be found, as long as civilisation exists, and as long as mankind has a history, be it thousands or be it ten thousands of years hence, men and even children will be taught to speak with reverence of the days in which we now live—of the age of the great Queen Victoria—and to point out on the map the little sea-girt island in the northern seas in which these wondrous discoveries had their birth.

* *Scott's Magazine.*

THE NEW GENERATORS OF ELECTRICITY.*

Study of the Reactions occurring in Them.

BY M. DU MONCEL.

The induction effects resulting from the relative motions of an inductor and a body under its influence are not generally taken into account with any exactitude, and, in consequence, some very inaccurate theories have been put forward in relation to several dynamo-electric machines which have recently been devised. The following series of experiments may be of use in fixing one's ideas in this direction:—

Let us suppose a few turns of insulated wire to be wound round a strong bar magnet, the extremities of this wire being connected with a distant galvanometer, and let the helix thus formed be sufficiently movable to allow of its position being shifted on the magnet. Now, if this helix be placed at the south pole of the magnet, and if an armature of soft iron be approached to this pole, we shall immediately obtain a current the direction of which will correspond to that of a magnetising current, and which is caused by the augmentation of magnetic energy due to the presence of the armature. This current will produce a deflection of (say) 12° to the right, and when the armature is withdrawn a second current of 12° to the left will be obtained; consequently, in the following experiments, a deflection to the right will represent an *inverse*, and one to the left a *direct* current.† Let us now examine what will take place when the helix is moved in various directions from the poles towards the neutral line of the magnet, and *vice versâ*. The following is what will be observed:—

1. When the helix is moved from the south pole to the neutral line a deflection of 22° to the right will be obtained; that is to say, an *inverse* or magnetisation current.

2. When this movement is reversed, another current is generated, producing a deflection of 25° to the left; and this current is consequently *direct*.

3. If, instead of bringing the helix back from the neutral line towards the south pole, the first movement is continued towards the north pole, a second current will be obtained in the reverse direction to that of the current due to the movement over the first half of the distance between the poles; and if the movement be arrested when the helix has reached mid-way between the neutral line and the north pole, the deflection will be 12° to the left.

* Translated from *l'Electricité*.

† It should be observed that the direction of the currents, due to the augmentation or weakening of a magnet, is the same, whether we act upon the north or the south pole, or upon both simultaneously, and whatever may be the position of the helix upon the magnet. Only the currents will be stronger as the excitation takes place nearer to the helix. Thus, if we place the helix at the middle of the magnet, or at the neutral line, the "current of surexcitation" which will result from placing an iron armature upon either of the poles will be inverse, and will produce a deflection of (say) 2°; whilst the current produced by withdrawing the armature will be direct and of the same intensity. By reacting simultaneously upon the two poles, by means of two armatures, the current will be in the same direction, and its intensity will be expressed by 7°. If the helix be placed at one of the poles, the south pole for instance, the currents of surexcitation and weakening will be from 10° to 12° when the armature is placed upon or removed from the south pole; whilst they will be only 4° when the north pole is reacted upon, and only 9° when the armature acts on both poles simultaneously. When the helix is placed half-way between the north pole and the neutral line, an inverse current will again be produced when an armature is approached to either of the poles; but it will now be only 5° when the north pole is reacted upon, and 2° when the south pole is affected. When an armature is simultaneously applied to both poles, the deflection will be 9°; and the effect will, of course, be reversed when the armature is withdrawn.

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4. By bringing the helix from this last position towards the neutral line, a deflection of 10° to the right will be obtained.

It follows from these experiments that the induced currents produced by the movements of the helix along the magnet behave as if the neutral line represents a *resultant of all the magnetic actions in the bar*. If this resultant were represented by a line in the direction of which the whole magnetic current passes, the current produced by moving the helix towards this line should, according to the law of Lenz, be *inverse*; and this is actually the case, since by moving the helix from either the north or the south pole towards the neutral line, the deflection is to the right. On the other hand, the currents produced by moving the helix away from this line should, according to the same law, be *direct*; and this is what is actually observed, since the deflections are then to the left.

It will be understood therefore that, in accordance with these considerations, a small helix movable around a magnetised ring should be traversed by a *direct* current when it moves from the neutral line, of one of the semi-circular magnets constituting this ring, in the direction of the inductor which polarises the latter; and this, in fact, is what we observe in the Gramme machine.

Let us now examine what would result from the passage of the helix in front of the inducing pole itself, which, we will suppose, is the south pole of the preceding magnet. But, instead of taking the little helix of which we have hitherto spoken, let us take a real coil, or bobbin, of small thickness, and capable of sliding upon a long rod of iron answering the purpose of a magnetic core. In order that we may be able to judge as to the direction of the currents which we are to observe, we will commence by examining the direction of the current which will be generated when we approach, towards the south pole of the inducing magnet, the bobbin just referred to—the anterior end of which, that is to say, the end which, in the following experiments is in front, will first be presented to the pole in question. Under these conditions we shall obtain a deflection of 25° to the right, and, by withdrawing the helix, one of 22° to the left. This is a reproduction of the well-known experiment of Faraday, in which we understand that the deflections to the right represent *inverse* and those to the left *direct* currents.

Now, if we take the bobbin in question, and cause it to pass from right to left, and *tangentially*, in front of the south pole of the inductor, taking care to produce this movement in two stages, we shall observe:

1st, That in the first half of the movement, a current is developed which determines a galvanometric deflection of 8° to the left; and that, in the second half, another current is produced, giving 5° in the same direction.

2nd, That, by reversing the direction of the motion, the direction of the currents is also reversed.

We may, therefore, conclude that *the currents resulting from the tangential movement of a helix in front of a magnetic pole* are produced under conditions altogether different from those which prevail in the case of currents resulting from the movement in the direction of the axis of the magnet. These two movements in fact occur not only in two directions perpendicular to each other, but also under conditions which differ in relation to the mode in which the induction takes place in the different portions of the helix. In the case of the tangential motion, induction is exerted only upon one half of the circumference of the turns of wire, and it acts on each side through different ends of the helix. In the other case, it is not so; the relative positions of the different portions of the helix remain under the same conditions in respect to the inducting pole, and it is only the position of the resultant which varies.

There remained to be ascertained what occurs when the bobbin, moved as above described, is subject to the action of a magnetic core influenced by the inductor; and in this case it is only necessary to slide the bobbin upon the long iron rod of which we have spoken whilst this is exposed to the action of the inducing pole. By thus proceeding, the following effects are observed:—

1. In the first place, when the iron rod is approached towards the inducing pole, though maintained at a distance from it sufficient to allow of the movement of the bobbin between it and the pole, there is produced in the coil, situated on one side of the pole, an induced current resulting from the magnetisation of the bar, and which gives a deflection of 39° to the right. And the deflections on this side correspond to the *inverse* currents.

2. When the bobbin, placed as in the first series of experiments, is set in motion from right to left, it produces, at the moment when it arrives beneath the inducing pole, a current of 22° to the left, which is, consequently, a *direct* current; and by continuing the movement beyond the inducing pole a fresh current in the same direction, giving 30° to the left, is obtained.

The effects produced by the passage of the bobbin in front of the inductor are thus in the same direction, with or without an iron core, but are much more energetic with it. It may, therefore, be said that the currents generated in consequence of the displacement of the helices on a Gramme ring, relatively to the two resultants corresponding to the two neutral lines, are in the same direction as those produced by the passage in front of the inducing poles of the turns of wire in the helices in each half of the ring.

In order to study the effects resulting from *polar interversions*, the experiment may be arranged in the following manner:—

We take the rod of iron provided with the induction coil previously referred to, and we slide a permanent magnet over one of its extremities, perpendicularly to its axis.

In this manner the rod undergoes successive interversions of polarity, and it is found, not only that by this action alone a more energetic current is produced than the magnetisation and demagnetisation currents which result from the action of one pole of the magnet, but, further, that this current is not instantaneous, but appears to augment in energy until the interversion of the poles is complete. The direction of this current varies according to the direction of the movement of the magnetised bar, and if we compare it to that which results from the magnetisation or the demagnetisation of the magnetic core under the influence of one or the other of the poles of the magnetised bar, it will be found that it is *exactly in the same direction as the demagnetisation current determined by the pole which has first acted*; it is consequently in the same direction as the magnetisation current of the second pole; and since, in the movement performed by the magnet, the magnetic core becomes demagnetised in order to become magnetised in the contrary direction, the two currents which result from these two consecutive actions are in the same direction, and consequently form one current occurring throughout the whole movement of the magnet. On the other hand, the movement of the magnet in the opposite direction, having the effect of producing at the commencement a demagnetisation in the contrary direction to that operated in the first case, the current which results from this retrogade movement must be in the direction contrary to the first.

If we now revert to the effects produced by our magnet acting upon our movable helices perpendicularly to their axes, we can understand, in accordance with what precedes, that the displacement of the magnetic polarity of the core most directly surexcited by the inducing magnet, having for its effect the interversion of the contrary polarity of this core, in front of and behind the points successively influenced, the result must be that the different portions of the core of the helices successively constitute a series of magnets with interverted poles, analogous to those of which we have just analysed the effects, and which will occasion those currents in the same direction which we have observed, which currents will change in direction according as the helices travel from right to left, or from left to right.

If we repeat the experiments described at the commencement of this note, with a rod of iron converted into a magnet by the influence of two opposite magnetic poles applied to its two extremities, we shall observe some particular effects which have a real interest. For this purpose I employ an electro-magnetic arrangement, similar to that used by Faraday in investigating the action of magnetism upon light. But, to simplify matters, I take an electro-magnet, with very long arms, one of which being deprived of its magnetising helix can receive the small travelling bobbin or coil of which I have spoken above. When a powerful current is passed through this electro-magnet, whilst an armature is applied to its poles, the naked arm becomes a magnet, of which the poles are excited at one end by the base plate, and at the other by the armature. Consequently, by moving the bobbin from one to the other end of this naked arm, I might have expected to obtain the same effects as with my persistent magnet. Nevertheless, this was not the case, and the following are the results which I obtained:—

1. At the moment when the electro-magnet was excited, a magnetisation current was produced in the system, and, the bobbin being placed against the base plate, this current produced a deflection of 90° to the right.

2. By moving the bobbin towards the middle of the bar, there was a deflection of 5° to the left; and by continuing the movement in the direction of the armature, the deflection, instead of indicating a current in the contrary direction, was again 5° to the left.

3. By reversing the movement, a deflection of 5° to the right was obtained when the bobbin was moved from the armature to the middle of the rod, and one of 4° was produced by the motion from the middle of the rod to the base-plate of the electro-magnet.

Now, it appears to result from these experiments that the iron rod, instead of being polarised in inverse direction at the two ends, behaved as though it had only the polarity of the base-plate; and if we consider that the only difference between the two modes of communicating polarity is merely that, on the

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one hand, the rod was screwed to the base-plate, whilst on the other it was only in simple contact with the armature, we might conclude that the contact of two magnetic bodies does not establish between them a magnetic conductivity sufficient for such contact to be equivalent to one produced by a strong pressure. The same thing is observed in the case of electrical conductivity when two portions of metal are in contact; the conductivity is perfect only when a strong pressure is applied.

In order to assure myself of the truth of this explanation I fastened the armature to the poles of the electro-magnet by means of screws, and under these conditions the effects took place as though the rod constituted a true magnet.

By duly taking into consideration these various principles, all the effects produced in the Gramme, Siemens, and Meritens machines may readily be explained; and I cannot too strongly advise those who take an interest in induction machines to repeat these different experiments.

SOCIETY OF TELEGRAPH ENGINEERS.

A meeting of this society was held on Thursday last at the Institute of Civil Engineers, Great George-street, Westminster, when Professor D. E. Hughes read a paper on "Experimental Researches into means of preventing induction upon lateral wires." The chair was occupied by the president, Lieut.-Col. Bateman-Champain.

The LECTURER, who was warmly received, in the course of his paper stated that the induction upon lateral wires had of late years been a serious question upon telegraph lines. The constantly increasing number of wires upon the same poles, added to the adoption of high speed and consequent sensitive apparatus, rendered the study of these effects of the first importance. The disturbing effects had become each year more and more remarkable, and in 1868, by the desire of the French Telegraph Administration, he undertook a series of practical experiments, with the view of finding a remedy. He found they had to deal with a question of a more complicated nature than was at first supposed. He then gave a very interesting *résumé* of the results obtained in the course of the experiments which were made. They made use of three separate and distinct means of research, and he proceeded to describe these means, alluding to the difficulties met with, and the various measures taken to remove them. Having referred in detail to some eight sets of experiments with coils, he directed the attention of the meeting to an instrument which he said he was able to place before the public for the first time that evening. It consisted of a series of coils of insulated iron wire. Their object, however, was not to bring forward new instruments, but to discuss the question generally, and he would therefore at once sum up his conclusions. He then observed: There are three points on ordinary telegraph line, or lines, where we may attempt a solution of the difficulty by compensation or other neutral effects—namely, the receiving, intermediate, and transmitting stations. At the receiving station ordinary induction coils, or the compensating coils described, would be injurious, as they could not be reversed in relation to each other, and would thus increase the induction. Voltaic currents direct, or by derivations from the primary line, would answer only where the signal consisted of a dot on a short signal exactly equal in duration and force to that of the induced current. Polarisation batteries direct on line would allow the induced current to pass, and if used as a derivation would require a very great resistance, and would allow the extra current from the working electro-magnet to affect all the rest. Condensers would be similar to the polarisation or secondary batteries. Resistance coils would reduce the induction, but also in equal proportion would reduce the voltaic current needed. Magnetic condensers would absorb the induction, but would also absorb the first part, or the part most needed, of the voltaic current. At the intermediate station all these would give contrary effects to those desired, except secondary batteries and condensers on derivation, but these would weaken the primary current, and for a line of ten wires would, from a calculation he had made, require forty-five such condensers, and even then it would be impossible to fulfil all the necessary requirements. At the transmitting station ordinary induction coils could not be used, except for a line of two wires only. Derivations from a secondary battery would require that a great resistance between line and earth should be introduced; and, moreover, the current would be prolonged beyond the induced current. Polarisation batteries and condensers would also, and in derivation, require great earth resistance, and would require for a ten-wire line the same number of condensers as the intermediate station with like results. Compensating coils as arranged in the instrument he had submitted fully meet the difficulty, giving perfect compensation for any number of wires with but one coil to each wire, provided that the lines are used for transmission in one direction only for stated periods, and that they are arranged as in France as already explained (all arranged in one plane, or nearly so). The perfect line, however, itself, quite free from induction and not inducing on other wires, and, therefore, requiring no compensating arrangement, is a double wire mentioned by the lecturer, where both ends are to earth, and its electro-magnet wound differentially. We have studied this subject with much interest, because we believe that the future improvements in telegraphing depend, in a great measure, on its entire solution, and we hope that by a discussion on this subject new facts may be brought to light. Subsequently, Professor Hughes made a few experiments with his instrument, above described, and observed that he had made several experiments, but that was the only instrument which had answered all requirements, as far as the laboratory went. It had never yet been tried on lines, but still it was satisfactory to have vanquished all difficulties in the laboratory; for, when it worked perfectly in the laboratory, it could be tried on lines. So far, this instrument had succeeded. He then resumed his seat amid warm applause.

The PRESIDENT thought, as the hour was late, that they would allow him to return their very hearty thanks to Professor Hughes for his paper, and to congratulate him on the great success of the experiments he had just made before them. Thanks having been enthusiastically accorded to Professor Hughes, the President continuing, said it was his duty to announce the adjournment of the meeting till Wednesday, the 26th, when it was the intention to have, if any gentleman desired to speak on the subject, a short discussion on Mr. Cowper's paper read at the last meeting. A paper would afterwards be read on a subject of very great interest to them all about the present moment, and drawn up by an old colleague of theirs, Professor Sivewright. The paper was entitled, "South African Telegraphs," and it would be the "standing dish" for their next meeting.

The proceedings then terminated.

ELECTRICITY AS A SOURCE OF LIGHT.*

BY PROFESSOR REDWOOD.

(CONTINUED FROM PAGE 132.)

Even at that period, however, and with the means then available, there were men—practical and scientific men—who not only believed in the feasibility of making the electric light applicable for many if not most of the purposes for which we require artificial light, but who considered that it could be obtained at no greater cost than that usually incurred in producing by other means an equal amount of light of inferior quality. Many men were then as now enthusiastic on the subject. Patents were taken out and companies formed for introducing the electric light as a substitute for gas light. In fact there was just the same sort of excitement on the subject, although not the same amount of it, then as exists at the present time.

It was under such circumstances, and for the purpose of showing what was being done or proposed to be done, that I undertook, in the early part of 1849, to explain and illustrate the subject as far as means at my command admitted. Much of the apparatus I have here now was what I used on that occasion, and I may refer the younger portion of the audience to the eighth volume of the first series of the *Pharmaceutical Journal* for a report of the brief exposition then given of the fundamental principles involved in the application of electricity as a source of light.

And now after a lapse of thirty years we meet here again for a similar purpose to that which brought us together before, and the first question that presents itself is,

"What has been done during those thirty years, and how comes it that we are here discussing the subject of electric light as if it were a new subject?"

With reference to the first part of this question it may be said that after many trials of many forms of apparatus, some of which were identical with some of those now again patented, it was found impracticable to accomplish what was required. None of the proposed forms of apparatus could be relied upon for supplying a constant light without continued personal attention, and no method was known by which the current could be broken up so as to be distributed to an indefinite and varying number of lights. From a single motive power a single light of great intensity could be obtained, but the intensity of the light, while it adapted it for some purposes, rendered it unsuitable for general

* Substance of a lecture delivered before the Pharmaceutical Society of Great Britain, Wednesday, January 8, 1879.—(From the Journal of the Society.)

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use. Faraday, at a meeting of the British Association in 1849, in a discussion on the electric light, remarked on the inapplicability of it for purposes of general illumination, stating that objects not directly illuminated appeared dark when the eye was embarrassed by the intensity of the light. The result was that it came to be considered a very suitable light for lighthouses, but not for the ordinary purposes of house and street lighting. And even for use in lighthouses the galvanic battery could not be relied upon for supplying a constant and sufficient current without incurring undue expense.

Then with reference to the latter part of the question it may be said the subject of electric lighting has two phases, one relating to the feasibility of applying for the proposed purpose the electricity developed by galvanic batteries, and the other relating to the application for the same purpose of the electricity produced by mechanical action; that in regard to the first part of the subject, the question was answered in the negative thirty years ago, but that with regard to the second, the question remains to be answered, and that thirty years' experience, coupled with practical demonstration of results, seem to justify the anticipation of at least a more favourable answer than would have been looked for some years ago.

It is therefore to the use of the magneto-electric machine, as the source of dynamic electricity, that we are to look, if at all, for the successful introduction of the electric light.

It is well known that for many years past light thus produced has been successfully applied to lighthouses, and there are many persons who, influenced by this and the numerous other demonstrations of the light that have been recently made, are ready to conclude that all material difficulties in the way of its general use have been overcome, and that we may anticipate its speedy introduction not only into our streets but our houses. Others, however, being less easily satisfied, desire to know what new law in natural philosophy has been discovered to render that practicable now, which was pronounced to be impracticable thirty years ago.

With reference to this question I may say at once that I am not aware of any such discovery having been made; but of course I admit, what indeed is very evident, that the means of applying electricity for the production of light have been greatly extended and improved, and, as a result of this extension, the effects now produced, and the manner in which they have been recently brought before the public, are calculated to give the impression of their being at least partly founded upon some newly discovered principle.

If I were briefly and broadly to endeavour to represent what the general nature of the improvements and the manner of their introduction had been, I would say that they had been effected by the power and through the means that have, at nearly the same time, effected one of the greatest revolutions on record, which commenced in this country and has rapidly spread throughout the civilised world—a revolution, the effective agents of which are characteristic elements of our commercial prosperity, namely, iron, coal, and engineering skill. To these agents we are indebted alike for railroads, steamboats, and electric lighting.

We chemists were messing over our fuming acid pots, and wasting much valuable metal, when a great potentate, King Coal, stepped in, with a band of engineers and mechanicians, and fairly pushed us from our stools.

Electricity, in this application of it, has become a result of mechanical engineering. The chemical action with which we commenced, consisting in the combustion of zinc in strong acid, has been replaced by the combustion of coal and the modern motive power steam.

We thus find coal brought face to face with itself in another dress, as seen on the Thames Embankment and Holborn Viaduct. Let us hope that we shall not be tempted to exhaust our coal fields in an unprofitable contention between gas and electricity, or a useless attempt to violate the laws of nature by converting night into day.

When railroads were first introduced, it was predicted that horses would cease to be required, and that they would probably become wild animals of our woods; and now that the electric light has become a realised fact in our streets, shops, and factories, equally rash anticipations are formed of the extent to which this new light is to supersede the use of gas. The actual result will probably accord in the latter case with what it has proved to be in the former. Both will find their appropriate applications, the one supplying, as at present, sufficient light for ordinary purposes, and the other affording a more intense light for special applications. I very much doubt whether we do not, even now, use more artificial light than is good for us, which, to a great extent, arises from what has been and will continue to be a strong inducement to the use of gas, that as compared with the electric light it is what the horse, as a means of locomotion, is in comparison with railroads. It is docile and accommodating. We can provide and store it, and use it as required. From the storehouse or stable we can lead out a supply for an army or for an individual, and we can break up the supply, whatever it may be, into an indefinite number of branches of various dimensions. We can take it at a walk, a trot, or a gallop, at pleasure, turn it here or turn it there with the greatest ease, and provide for every requirement as it arises.

On the other hand, the intensity of the electric light may be compared to the speed of the railway train, while the ease and luxury with which locomotion is effected by the latter may be compared to the purity of the new light, and this intensity and purity cannot fail to be appreciated where such light is required.

It is quite possible, and I think very probable, that large fixed electric lights, where one, or at most half-a-dozen—but the fewer the better—are fed from one common current of electricity, may be provided at less cost than that at which an equal amount of light could be otherwise produced.

There is no doubt, therefore, that the electric light has an important future before it, and we are all anxious, as far as we can, to form a tolerably correct judgment as to what that future will be, and what the means are by which it will be realised.

(TO BE CONTINUED.)

TELEGRAPH SHARE LIST.

Companies.	Closing Prices March 12.		Business Done Week Ending March 12. Highest.	Lowest.
Anglo-American	57½,	¾	58¼	57½
Do. "B"	86½,	¾	86¾	86½
Do. "A"	29,	½	30	29½
Brazilian	6¾,	¼	6 15-16	6¾
Cuba	8,	½	—	—
Do. Ten per Cent. Preference	15,	½	—	—
Direct Spanish	1½,	2	—	—
Do. Ten per Cent. Preference	10½,	¾	—	—
Direct United States	11½,	¾	11¼	11¼
Eastern	7 5-16, 7-16		7¼	7 5-16
Do. Six per Cent. Debenture	104,	107	105¼	—
Do. Five per Cent. do.	100,	102	—	—
Do. Six per Cent. Preference	11½,	¾	11¾	11½
Eastern Extension	7 5-16, 7-16		7 7-16	7 5-16
Do. Six per Cent. Debenture	104,	107	—	—
German Union	7¾,	8¼	8¼	—
Globe Telegraph and Trust	4 15-16, 5 1-16		5 1-16	4¾
Do. Six per Cent. Preference	10 5-16, 7-16		10½	10½
Great Northern	8½,	¾	8¾	8½
Indo-European	20½,	21½	—	—
Mediterranean Extension	2½,	3½	—	—
Do. Eight per Cent. Preference	9,	½	—	—
Reuter's	9½,	10½	—	—
Submarino	218,	223	222	220½
West India and Panama	1¼,	2½	2	1 15-16
Do. Six per Cent. Preference	8½,	¼	8 11-16	8½
Western and Brazilian	4,	½	4¼	3¾
West. Union Seven per Cent. 1st Mort.	114,	118	—	—
Do. Six per Cent. Sterling	100,	102	101½	100¾

TRAFFIC RECEIPTS FOR FEBRUARY, 1879.

Companies.	Feb. 1879.	Feb. 1878.	Increse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800 estd.	2,818	—	18
Direct Spanish Telegraph Company	784	814	—	30
Direct United States Telegraph Company	14,180	—	—	—
Eastern Extension Telegraph Company	22,409	20,716	1,693	—
Eastern Telegraph Company	37,251	41,831	—	4,580
Great Northern Telegraph Company	12,087	—	—	—
Submarine Telegraph Company	8,658	9,257	—	599
West Coast of America Telegraph Company.	2,400	1,425	975	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

ELECTRIC TELEPHONES.—Professor Barrett announces that the new receiver, devised by Mr. Edison to be used with his carbon telephone transmitter, had just arrived in England in charge of the inventor's nephew. This new receiver has no ear-piece, and can, it is said, deliver the voice as loud as the words are spoken. The principle on which this receiver depends is the same as that of the electromotograph discovered by Mr. Edison in 1874. A band of moistened paper moves below a point, and as the current passes the point slips more or less. This slipping is the source of sound in the receiver, further particulars of which may be given shortly.

RAPID TELEGRAPHY.—Since the opening of the Parliamentary Session two new wires have been worked simultaneously and continuously between London, Dublin, Cork, Belfast, and Londonderry, at the unprecedented speed of 130 words per minute. It is understood that the Post Office authorities have recently been making very great improvements in their fast-speed apparatus.

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NOTES.

DR. HIGGS'S LAMP.—According to Mr. Hedges, "Dr. Higgs employs an infusible earth, rendered conductible, so that if the conducting material be fused, the circuit is not broken."

A FIELD TELEGRAPH FOR NATAL.—Lord Chelmsford has asked that he might be supplied with a field telegraph, and accordingly the men and materials are to be despatched at once.

"USEFUL INFORMATION ON PRACTICAL ELECTRIC LIGHTING."—A second edition of this useful little work by Mr. Killingworth Hedges has been called for, and some slight additions made to its contents. The information is by no means original, but it is in a compendious form, and so arranged that a general idea of the subject may easily be obtained by any one who has no time to dig deeply into the scientific question.

ANOTHER EXHIBITION.—New York is to have a World's Fair in 1889, the centennial anniversary of the foundation of the Government. A great public meeting (says the *Operator*) will be held in New York on April 30 next—the nineteenth anniversary of the union of the States, and of the inauguration of Washington as the first President—to make arrangements for the International Exhibition in 1889. Dr. Norvin Green, President of the Western Union Telegraph Company, is one of the Executive Committee.

CUTTING TELEGRAPH WIRES.—The telegraph wires have become so common in England that, as a rule, even the mischievous animal *genus* boy has lost all interest in playing pranks with them. Exceptions, however, to the rule sometimes arise. Hence, we hear that two youths stopped telegraphic communication between Widnes and Liverpool on the 8th of March by cutting the wires with a piece of tin. It is to be hoped that these boys were scientifically inclined, and having their curiosity excited by a lesson at school, were endeavouring to increase their knowledge by a practical experiment. They were reminded, however, that knowledge must be obtained with difficulty, inasmuch as stern justice demanded a slight payment in the shape of £9 and costs, or a month's seclusion at the county's expense.

AN EXPERIMENT OF SIR H. DAVY'S WITH THE ELECTRIC LIGHT.—"Mr. Pepys having had the goodness to charge the great battery of the London Institution, consisting of 2,000 double plates of zinc and copper, with a mixture of 1,168 parts of water, 108 parts of nitrous acid, and 25 parts of sulphuric acid, so as to make an arc, or column of electrical light, varying in length from one to four inches, according to the state of rarifaction of the atmosphere in which it was produced, and a powerful magnet being presented to this arc or column, having its pole at a very acute angle to it, the arc or column was attracted or repelled with a rotary motion, or made to revolve, by placing the pole in different positions, being repelled when the — pole was on the right hand by the north pole of the magnet, and attracted by the south pole, and *vice versâ*,"

THE QUANTITY OF ELECTRICITY REQUIRED FOR THE COMPLETE CHARGE OF A PLATINUM WATER CELL.—According to a Note in the *Journal* of the Chemical Society, H. Herwig has determined that the quantity of electricity required for the complete charging of a platinum water cell to the potential difference of 1 volt is equal to 0·000186 Veber, when the plates have a surface of 1 sq. cm. The value is independent of the distance between the plates and of the external resistance. In order to derive from this the charging value for a potential difference of 1·7 volts, it is necessary to multiply by (1·7 × 1·25), which gives 0·000395 Veber. By means of this value and the application of his theory of rotary electrolytic molecules, M. Herwig has determined directly the distance between the molecules of water, and finds it to be at most $\frac{186}{1,000,000,000}$ mm. Lorenz found, by a similar, although less direct, method, the superior limit, $\frac{100}{1,000,000,000}$ mm, and Sir W. Thomson, by an entirely different method, the inferior limit, $\frac{50}{1,000,000,000}$ mm.

NEW PHENOMENON OF VOLTAIC ELECTRICITY.—M. Sergius Kern sends to the *Monthly Journal of Science* an account of a very interesting experiment by M. Slonginoff, which is likely to be fruitful in physical research. He takes as the two electrodes of a battery a thin plain platinum plate, placed horizontally, and a platinum wire placed perpendicularly to the plate and nearly in contact with it. A small quantity of water acidulated with sulphuric acid is poured on to the plate. If a current from a battery of eight to ten cells be passed through this arrangement, a spot of light is observed on the point of the wire when this constitutes the cathode. With fifteen couples the light appears even when the direction of the current is reversed. During the phenomenon the water is only slightly decomposed, and the needle of a galvanometer introduced into the current is only slightly deflected. It was also remarked that the surface of the water under the wire is depressed, taking the form of a cup. The bubbles of gas arising from the decomposition of the water, in this case, travel constantly round the wire, forming a very pretty figure of 8. It was further discovered that during these actions in the apparatus the current is intermittent.

AUGMENTATION OF VOLUME PRODUCED BY A STATIC CHARGE.—At the Société Française de Physique, M. Duter recently referred to his demonstration of the fact that the cubical capacity of a Leyden jar becomes augmented when the latter is charged, returning to its original value when discharge takes place. He further announced that the change of volume in question is proportional to the square of the distance at which disruptive discharge takes place, and, consequently, to the square of the difference of tension of the two armatures. In jars of equal capacity, it is also inversely as the thickness of the glass. This latter fact sufficed to establish that the observed phenomenon is not due to the pressure exerted by the opposite electricities accumulated upon the glass surfaces; for the variation of volume which this pressure would tend to produce varies, it is true, as the square of the difference of tensions, but inversely as the *square* of the thickness of the glass. Again, the diminution of volume resulting from the electric pressure between the armatures, when calculated in accordance with the coefficients of compressibility of glass, would account for hardly one-seventh of the variation observed. The phenomenon dis-

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covered by M. Duter could not, therefore, have been foreseen from the laws of Coulomb.

America pokes Fun at Edison.—Mrs. Edison says that when Mr. Edison gets the electric light finished, and one other invention off his hands, he and the family will go to Europe, and stay two years. It may be just possible, however, judging from the progress already made, that the electric light will "finish" Mr. Edison before he finishes it. At any rate, an expectant public has been looking for the "finishing" of the electric light for many weary months, but Mr. Edison seems to be about as much in the dark in regard to it as he was at the beginning.—One of our correspondents not long since suggested an appropriate motto for the Edison light, "Keep it dark." Readers should take these sentences in the spirit intended, nor set down aught to malice. The world must laugh; let it laugh. Behold, then, what the *Operator* says:—"Edison's sister tells a good story of his boyhood. 'He tried to sit on eggs,' she said. 'What's that? How? What do you mean?' inquired the listener. 'Why he was about six, I should think, and he found out how the goose was sitting, and then saw what the surprising result was. One day we missed him, called, sent messengers, couldn't find him anywhere. By and bye, don't you think, father found him curled up in a nest he had made in the barn and filled with geese and hen's eggs—actually sitting on the eggs and trying to hatch them!'"

Electro-plating with Zinc.—The so-called galvanized iron is covered with zinc, not by galvanic action, but mechanically, the object being to protect it by galvanic action at the expense of the zinc. If it is desired to deposit a uniform layer of zinc upon iron or other metal by means of a battery, the following bath is employed:—10 parts of alum and 1 part of freshly precipitated hydrated oxide of zinc (still moist) are dissolved in 100 parts of water. This bath can only be used cold. The article to be plated is cleaned in an acid bath, attached to the negative pole of a battery, and immersed in the above bath. A large plate of cast zinc is connected with the positive pole. The current need not be very strong, and the zinc is deposited equally well upon all metals. If copper which has been zinc plated in this way is heated, a beautiful and thin layer of brass is produced on the surface. When iron is coated in this way, the strength of the coating increases upon warming the article, and the iron is completely protected from rust. The thickness of the coating, of course, is proportional to the time it is left in the bath. It must be borne in mind, however, that the zinc is poisonous, and such vessels should never be used either for culinary purposes or to hold drinking water, which objection does not hold in regard to the more expensive, but likewise more durable, nickel plating. For ornamental and architectural work, and some parts of machinery, zinc will prove a cheap and useful substitute.

Edison's New Telephone Receiver.—We noticed in our last issue that Mr. Edison had sent, by the hand of his nephew, Mr. C. P. Edison, a new telephonic receiver, which was said to surpass anything of the kind previously in use. Since then we have had several opportunities of examining this instrument, but it requires a still more extended use before the exact value of the apparatus can be ascertained. In the laboratory it works well. Several improvements, however, will be introduced, not in the vital parts of the instrument, but in the design and arrangement. It is understood that Mr. Edison had for the moment put forth all his energy in the elaboration of a system of electric lighting, and only sent these receivers at the urgent request of Colonel Gouraud. This will be seen from the following extract from a letter of Mr. Edison:—"Owing to your numerous telegrams I thought best to make two rough receivers and two telephones with transmitters, and send by my nephew, C. P. Edison. Please understand, and have others understand, that these instruments were made in five days, and are only experimental, and do not set the invention off to any advantage by any means. The whole arrangement will, however, show you what the invention is, and I think that it will replace every other kind of telephone in time." According to Mr. Prescott, the first conception of this instrument occurred on the 23rd November, 1877, and this has developed into the more perfect receiver now to be described. If readers will turn back to p. 16 in our issue of Nov. 30, 1878, they will find a short description of the original instrument. The following is taken from the *New York Herald*, and we have reason to believe is a description of the instrument by Mr. Edison himself. We shall illustrate and give our own description of the apparatus in our next issue:—"A diaphragm of mica four inches in diameter is held in a suitable framework. A hand crank is made to rotate a small chalk cylinder (previously impregnated with the proper chemical solution) with a continuous forward motion directly outward from the face of the diaphragm. One end of the metal bar is fastened to the centre of the diaphragm, and the other end rests upon the chalk cylinder, being held down very firmly by a spring. The circuit is made from this metal bar, through the chalk cylinder to the base. As the cylinder is rotated either by hand or other power, the friction between the metal bar and the chalk cylinder is very considerable, and the diaphragm is drawn or bowed outward toward the cylinder. This operation is purely mechanical and local. When the electric waves are transmitted from the distant station by the speaker (who uses Edison's carbon transmitter) over the wire to the receiver, each wave as it passes through the chalk cylinder effects by electro-chemical decomposition more or less neutralisation of the friction between the bar and the cylinder, according as the wave may be a strong or weak one. The resultant effect of each wave is the freeing of the diaphragm, permitting it to regain its normal position. Thus a series of electric waves, with the alternate space between, effects a vibration of the diaphragm in perfect accord with the voice of the speaker, the action being solely electrical and chemical. The element of time is not a factor as in the electro-magnetic instrument, where, as is well known, a perceptible degree of time is requisite for a charge and discharge. In this new telephone apparatus Edison dispenses entirely with the electro-magnet, heretofore used in all telephone receivers, substituting the electro-motograph principle. This, by its greater delicacy and power, is made to vibrate a very much larger diaphragm than is possible with the electro-magnet, thus giving greater volume of sound and obviating the necessity for holding the telephone to the ear. By it the voice of the speaker is transmitted to the distant station without the loss of volume. In fact, at times, with a very considerable increase, the telephone speaks louder than the person talking at the transmitting station. It also produces the highest musical notes with the same perfection as the lower ones, something that was found impossible in the old machine. These points of superiority over the electro-magnet are due to the fact that while in the electro-magnet the electric waves constitute the force which vibrates the diaphragm of the receiver, in the new machine they only control it, the force used being strictly local, either the power of hand or clockwork."

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FOUR LECTURES ON ELECTROSTATIC INDUCTION.

JAN. 16, 23, 30, AND FEB. 6.

BY J. E. H. GORDON, B.A.

(Assistant Secretary of the British Association).*

LECTURE IV.—FEB. 6.

SPECIFIC INDUCTIVE CAPACITY OF GASES.—ELECTRO-MAGNETIC THEORY OF LIGHT.

Faraday† made a great number of experiments on the specific inductive capacities of gases to see if he could detect any differences between them, but he was unable to do so. He compared no less than 25 pairs of gases. He also compared dry and damp air, and hot and cold air, and air at various pressures, but with his apparatus he could detect no difference at all.

It is curious to see how long and how earnestly he sought for evidence of differences of action.

He seemed to have so strong an instinct that there ought to be a difference that he literally struggled against the evidence that every experiment he made seemed to pile up against his theory. He knew that gases differed in so many of their other physical properties that he could hardly believe they were all alike in this one. He used the same apparatus as I showed you in the last lecture. It was not till last year that Professors Ayrton and Perry, working with apparatus many thousand times more delicate than that which was at Faraday's disposal, succeeded in showing that the reason why Faraday had not been able to detect differences of specific inductive capacities in gases was not that these differences did not exist, but that they were too small to be detected, except by a quadrant electrometer. Professors Ayrton and Perry have not only shown that different gases have different specific inductive capacities, but that the specific inductive capacity of the same gas is different at different temperatures and pressures; and, further, they have actually measured the amounts of these differences. Through the kindness of Professor Ayrton I am able to explain to you his method of working, but I cannot show you his experiments, as they were made in Japan, and the apparatus being the property of the Japanese Government had to be left behind when Professor Ayrton returned last August.

Professor Ayrton's method of working was as follows:—He prepared two condensers—that is, Leyden jars—into one of which he could put different gases as the insulator. One, which he called the "open air condenser," consisted of a thick brass plate laid on the table, having over it another brass plate. This latter was supported on three ebonite levelling screws. The two brass plates formed the conductors, and the air between them formed the insulator. You will see the use of this condenser immediately.

FIG. 28.

FIG. 29.

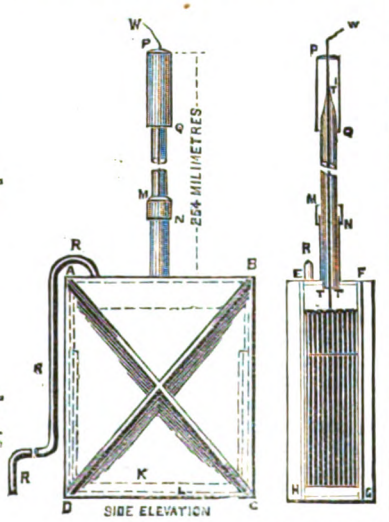

FIG. 30.

END ELEVATION
FIG. 31.

The other condenser was called the "closed condenser." It consisted of eleven brass plates, fixed parallel to each other, in a metal box. Nos. 1, 3, 5, 7, 9, 11 were all connected to one piece of metal, and Nos. 2, 4, 6, 8, 10 to another. The two sets of plates were insulated from each other. They thus formed a condenser of very large surface, and all the spaces between could be filled with the gas under examination. The brass box was closed quite air tight, and could be connected to an air-pump when required. The induction through this apparatus, when it contained

PLAN
FIG. 32.

different gases, could be compared. But it would be impossible to preserve a perfect record of the action through the condenser and to ensure that the inducing force should always be the same. For this reason the "open condenser" before mentioned was used.

The closed condenser was filled with dry air at ordinary pressure, and the induction through it was compared by means of a very delicate quadrant electrometer with that through the open condenser. This ratio was noted.

The closed condenser was then filled with some other gas, and the ratio again noted between it and the open condenser. The open condenser, of course, remained the same. The difference between these two results gave the difference in the inductive action through air and the gas under examination.

The open condenser, in fact, only acted as a standard measure, just as if it were desired to compare the lengths of two ropes, and it was not convenient to lay them together, they could each separately be compared with a yard measure.

The difficulties of this investigation must have been enormous.

Professor Ayrton's Paper contains quite a heartrending list of breakages, leakages, and twistings. He relates how, first, the box was not air-tight. Then a smith, having been sent for to solder it, his hot tools damaged the ebonite inside, and it all had to be taken to pieces again. Then the long glass tube in which the conducting wire was insulated broke again and again. Then, when all was finished, mercury from the air-pump got inside, and spoilt the whole affair.

We in England suffer in the same way, but can we imagine what the difficulties of delicate physical investigation must be when all repairs of instruments have to be done either by the experimenter himself or by Japanese workmen?

However, at last the skill and invincible patience of the investigators conquered all difficulties, and the results on this diagram were obtained:—

AYRTON AND PERRY ON SPECIFIC INDUCTIVE CAPACITIES OF GASES.

Dielectric.	Specific inductive capacity.	Dielectric.	Specific inductive capacity.
Air	1·0000	Hydrogen	0·9998
Vacuum	0·9985	Coal gas.....	1·0004
Carbonic dioxide...	1·0008	Sulphuric dioxide...	1·0037

These results are a marvel of experimental work. In some cases the whole difference which had to be measured was only two parts in 10,000. The maximum difference was only 37 in 10,000, and yet these differences have not only been observed, but have been measured so accurately that a mathematical comparison of the various observations of which they are the means shows that the probable error is not more than 5 parts in 100,000, or 1-200th per cent.

In future it will not be sufficient to say the specific inductive capacity of air is taken as unity. We must specify the pressure and temperature of the air, and say that the unit specific inductive capacity is that of dry air at 30 inches barometer and 32° Fahr. temperature.

We now come to perhaps the most important and interesting part of our subject, namely, the relations between electricity and light.

It is chiefly by the consideration of the connections which may exist between different forms of physical energy that we may hope to some day obtain a clearer notion of their actual nature.

Between light and electricity there are numerous and close relations and analogies. The form, however, in which electricity is most intimately connected with light is not the static form which we have been considering, but another called "electro-dynamic," or, because of its magnetic properties, "electro-magnetic." Hitherto in these lectures we have considered only bodies charged with electricity at rest. We have examined the induction of charged bodies, that is, bodies containing electricity, but containing a certain quantity not in motion. The only cases of the motion or flow of electricity which we have noticed have been the momentary motions which have accompanied the discharging or charging of conductors.

When, however, electricity, instead of being at rest, is *flowing* as a current—when, for instance, electricity is being drawn out of one end of a wire and constantly being renewed at the other—it obeys an entirely new set of laws, different from those which we have been considering. Now, I am not going to attempt in the half-hour which remains of the last of these lectures to give an account of the laws of electro-magnetic induction, but this much will be necessary, and, I think, sufficient as an introduction to our study of the relations between electric induction and light.

Electric (that is, electrostatic) phenomena are so closely linked in every detail with electro-magnetic ones, that any arguments which show that the same mechanism transmits electro-magnetic

* Delivered at the Royal Institution 1879.

† "Experimental Researches," vol. i., p. 406.

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induction and light will also hold for electrostatic induction, though I do not say but that the working of the machinery may be very different in the two cases.

"One mechanism for electric induction and light." This is Prof. Clerk Maxwell's theory, which every new measurement which is made helps to render more probable.

It is this theory which, when it is finally proved, and when some difficulties that now beset it are cleared away, as no doubt they will be, will tell us "what is light," "what is electricity." Let us consider it, and try and understand what it means.

I will give the substance of the preface to Maxwell's chapter on the subject, and then explain to you such of his arguments as I understand well enough to put into an unmathematical form.

Light is, all men of science are now agreed, a wave motion of a medium which we call the ether which fills all space, and probably permeates all bodies.

The sun expends energy, and sends it off from him. This energy travels through the dark planetary spaces until it falls on the eye, and then it is felt as light. When it falls on opaque bodies, part is reflected from them, and, falling on the eye, is felt as the light which makes them visible. Part penetrates them, and heats them. In what form did this energy which we know as light exist in the dark space between the sun and earth?

The undulating theory of light answers that this dark space is full of a medium, a very thin fluid, and that the energy given off from the sun is expended in producing waves in that portion of the medium next it, which in their turn expend the energy they have received in producing waves in the next portions, and so the energy is transmitted by these wave motions, until, on striking the earth or the eye, it becomes heat or light.

We have said that electric induction is a strain or distortion of the insulator through which it is transmitted. This medium may be air or glass or paraffin, &c., as we saw. But what is the medium when the sun acts inductively on the earth, as no doubt he does?

When a sun-spot bursts out into stronger activity all the magnetic instruments at Kew Observatory move in sympathy with it.

What is the medium which transmits this electro-magnetic induction from the sun to the earth? Professor Maxwell says that it is one and the same medium as that which carries the waves of light, or that *light itself is an electro-magnetic disturbance.*

Let us now consider some of the arguments which have led up to this theory.

It is proved, I think, that electric induction is a strain of some kind, and when electric induction passes through space in which there is not any ordinary matter we agree to call the unknown something that fills the space and transmits the strain an "ether."

Light is a strain of some kind, and when light passes through space where there is not any ordinary matter we agree to call the unknown something that fills the space and transmits the strain an "ether."

One word of explanation of the term "strain." In physics this word has a more extended meaning than in common language. Any change of form whatever is called a strain. A wave motion would, therefore, be called a strain.

How shall we decide whether these two ethers are one and the same? We must examine and measure as many of the properties of each ether as we can, and then, if we find that all the properties are the same, we shall be sure that the ethers are not two, but one.

If, again, we find that most of their properties nearly agree, but not quite, we must reserve our judgment; but we might, in that case, be allowed to speculate on the possibility of the same ether sea vibrating somewhat differently when disturbed by electricity or by light.

One important point of resemblance appears at once. In the case of light, the researches of Young, Fresnel, Hughens, and Green have shown that the energy in the medium is partly "potential" and partly "kinetic."

These are two hard words, but I think I can make their meaning clear to you.

"Kinetic" energy is the energy of motion, "potential" energy is the energy of strain. A stone when falling has kinetic energy. By virtue of its motion it can strike a hard blow on anything that comes in its way and stops that motion.

The same stone suspended by a string has potential energy, because the instant that the string is cut it will acquire kinetic energy. We may regard the earth and the stone together as a system which was strained when the stone was pulled away from the earth against the action of gravitation, and when the state of strain is released energy is developed as the stone falls.

Another illustration. Suppose a locomotive in motion, with full steam up.

Now, let the steam be shut off and the brakes applied. The engine does not stop at once, because it has kinetic energy, that is, energy due to its motion. It does not stop until the whole of this energy has been expended in heating the brakes and the rails.

When it is at a standstill, is all the energy expended? No, it is not, for even without burning any more coal we have only to turn on the tap, and the *potential* energy of the compressed or strained steam in the boiler is released, and, as the engine starts, is changed from potential into kinetic energy, and the motion continues until this again is expended in heating the brakes and rails.

Well, as I said, in the luminiferous ether, when carrying light vibrations, these two sorts of energy exist. The ether is in rapid vibrating motion, so has kinetic energy. It is also in a state of strain, so has potential energy. Note that I only tell you this, and have not given you any proof. The proof is a complex bit of mathematics.

The electric ether is also a receptacle of the two forms of energy, potential and kinetic; and here we can actually partly separate them and study them apart, for when static induction or the induction of electricity at rest is going on, the ether is strained, but is not being kept in motion, while, when electro-magnetic induction, that is, the induction of flowing currents of electricity, is going on, motions are produced and kept up in the ether, that is, it receives kinetic energy.

In the second case, however, it receives potential energy also.

Possibly the fact that, in the electrical case, we can partly separate the two forms of energy may at some future time throw light on the distribution of the potential and kinetic energies in the optical case.

There is another very important point of resemblance between electric and electro-magnetic induction, on the one hand, and light on the other.

It is this—

In light it is known that the waves are at right angles to the direction of the ray.

I mean that, if a ray of sunlight falls vertically on the earth, its vibrations are all horizontal.

You know that in this it differs from sound, as the vibrations of the air, which are sound, are in the same line as that in which the sound is travelling.

It becomes of great interest to determine in which direction the electric disturbance takes place.

I mean, if I hold this rod over this electroscope so that the line of force acts vertically downwards, then are the vibrations of the ether vertical or horizontal?

Prof. Clerk Maxwell has mathematically investigated this point, and has shown that the disturbances both of electric and electro-magnetic induction exactly agree with those of light in this respect, for they are both at right angles to the direction of the ray of electric or magnetic induction.

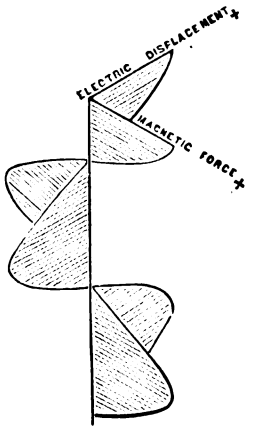

FIG. 33.

Further, he has shown that, if electric and magnetic induction take place together, the electric disturbance will always be at right angles to the magnetic one; that is, if the direction of the induction be vertical, the direction of the disturbances will be horizontal, and if the direction of one of these horizontal disturbances (say the electric one) be from N. to S., that of the magnetic one will be from E. to W. This diagram is from Prof. Maxwell's book.*

Another argument in favour of this theory is that it gives a real mathematical reason for the fact that all good true conductors are exceedingly opaque. All metals, for instance, conduct, and are opaque. The conduction of electricity by transparent liquids takes place in a different manner from the conduction by metals, and does not affect the deduction, *which is a necessary consequence of the theory*, namely, that all good true conductors must be opaque to light.

(TO BE CONTINUED.)

THE QUESTION OF "POTENTIAL."

BY M. DU MONCEL.†

The observations made by Mr. FitzGerald in *The Electrician* of Feb. 3, and which are reproduced in the last number of

* "Electricity," vol. ii., p. 390, Fig. 66.
† Translated from *l'Electricité*.

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l'Electricité, are the more surprising to me since he defends at the close of his communication what he attacks at the commencement.

In effect, he begins by expressing his surprise at my using the expression *tension of a current*, which, he says, cannot be justified by any scientific considerations, and he ends by demonstrating that the equations *based on the hypothesis of tension* are more simple, more readily understood, and constitute the expression of a physical fact. The word *tension* has, therefore, its *raison d'être*. But, precisely by this quiproquo, Mr. FitzGerald shows how necessary it is to have a better-defined term to express that property of electricity which is related to what he terms *electrical density*, and this term is exactly the word *potential*, which, moreover, is not new, since it has long been employed in mechanics, and is not always synonymous with tension, as will be seen.

I have never asserted that potential and tension are two different properties of the electric fluid; but I have stated, and I repeat, that the word tension, as it is generally interpreted in France, does not define with sufficient accuracy the properties relating to it to allow of its being taken as a basis for rigorous calculation. No doubt, if we take the word tension in the sense which Ohm seems to have attributed to it in his equations, we come to confound the two expressions in one; but Ohm himself was so embarrassed to designate this property, that he refers to it under many different names, such as *electroscopic force*, *electroscopic manifestation*, *power*, *energy*, *electrical condition*, and for this reason it is a difficult feat to make out what is meant in his different memoirs.

As to the effects produced, it mostly happens that they may be interpreted in the same manner; thus, it is quite true that *electromotive force* is represented by *the difference of tensions* as well as by the *difference of potentials*; but it sometimes happens that potential could not explain the effects produced; and, in proof of this, I need only take the case cited by Mr. FitzGerald, of a conductor in the form of a point, and statically charged. In this case the electrical potential is the same at all points of the surface of the body, and yet the fluid is in a manner urged towards the pointed end, since it flows therefrom in the form of an aigrette, or a silent effluence. Now, in virtue of what force can this flow occur, if not by an excess of tension, which the fluid possesses at this point? This, moreover, is what results from the calculations of Poisson. Again, it does not follow that, because a difference of potentials, as well as a difference of tension, constitutes the electromotive force, the properties belonging to the former and the latter are the same; for a difference may remain constant with elements very variable in the properties attributed to them.

What seems to me to result from the observations of Mr. FitzGerald is that he would wish to substitute the new expressions—*magnitude* and *density* for the terms *quantity* and *tension*, which we employ in France, and which correspond well with the ideas we have in relation to them, especially if we adopt as a corrective of the latter the designation of *potential*, which defines tension under given conditions. We are, therefore, surprised that the enemies of the new expressions should be so numerous in the direction taken by Mr. FitzGerald.

AN ELECTRIC LAMP FOR SURGICAL AND DENTAL OPERATIONS AND EXAMINATIONS.

On the 13th inst. Mr. Balmanno Squire, M.B., gave a lecture at the United Service Institution, in which he described and exhibited a portable electric lamp devised by him for the use of surgeons and dentists. The lamp in question (Fig. 1) is formed of a spherical case of metal, four inches in diameter, furnished with openings above and below to allow of the passage of a current of air, and fitted on opposite sides with a short and a long tube.

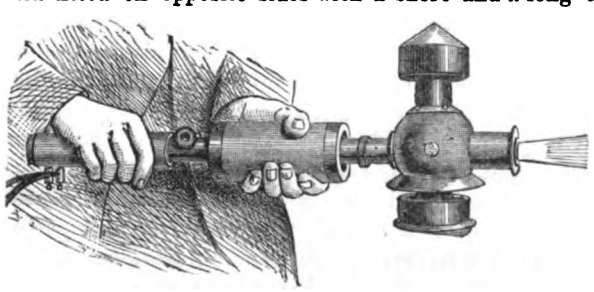

Fig. 1.

The former tube contains a lens or plate of ground or opalescent glass for the purpose of moderating the light, whilst the latter holds a cylinder to which is attached a Jablochkoff candle, which may be moved backwards and forwards within the tube by means of a rack and pinion. The position of the light within the metal case may be observed through a plate of dark blue glass inserted in one side of the casing. In addition to the hand lamp or lantern, the lecturer exhibited another (Fig. 2) capable of being readily fixed and adjusted in any required position. The electric current was obtained through conducting wires communicating with one of the dynamo-electric machines supplying, at a later hour, the electric lights on the Thames embankment; and the same source furnished the current for two large lamps, with globes of opal glass, which illumined with a soft and brilliant light the theatre of the institution. The lecturer stated that the lamp, as devised by him, would burn uninterruptedly for at least one hour and a half, and that at the expiration of that period a fresh candle could be inserted within a couple of minutes. He then described at some length the difficulties experienced by surgeons, dentists, and more especially by aurists and laryngotomists, owing to the want of a light of sufficient intensity and whiteness, capable of being directed in any required direction. The appearance of the larynx and of the tympanum is very different when these organs are examined by yellow (gas) light and by daylight, and this difference leads to an uncertainty of diagnosis which would be removed if the pure white light produced by electricity were substituted for that of gas. Unfortunately, it is at the present moment difficult to obtain a one-light dynamo machine; and a four-light machine, as supplied by the *Compagnie Générale d'Electricité*, costs £180, or, together with the steam-engine for working it, about £300. But a one-light machine, together with a suitable gas-engine, would cost about £100, and many surgeons and dentists in good practice might afford this sum in view of the great advantages to be obtained by the use of the electric light. When several professional men requiring this light reside in proximity to each other the same machine and engine might advantageously be made to do duty for them all. As a matter of fact, it pays several photographers in Regent-street to employ the electric light, and the application of the latter for surgical purposes might to be equally practicable in a pecuniary sense. In hospitals, the question of expense would be of small moment as compared with the importance of the applications in question. A travelling apparatus for the production of the light, furnished with a considerable length of insulated wire, to allow of operations being performed at the houses of patients, would seem to be quite within the limits of practical enterprise. On board our ironclads, the appliances for the production of the light might be readily provided where they do not already exist; and the wretched candle-light, constituting a continual source of danger, by which the cockpit is illuminated when operations have to be performed during or after an action, should become superseded by the light due to the electric current.

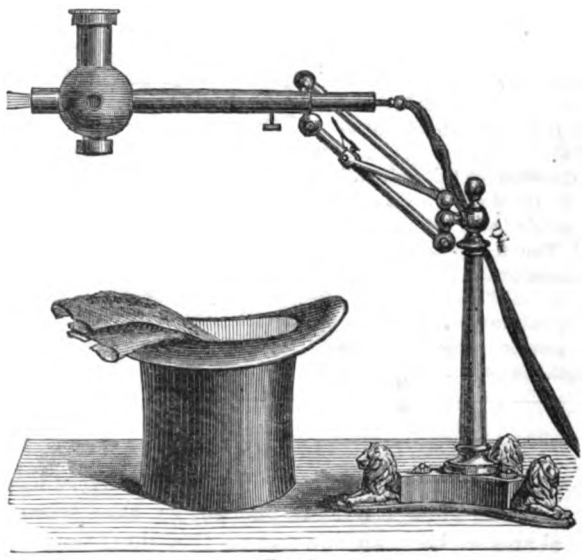

Fig. 2.

The use of the lamp, in conjunction with reflectors, a laryngoscopic mirror, tongue-depressor, &c., for the illumination of the uvula and upper portions of the trachea was well illustrated by the lecturer, who concluded his observations by a brief description of the principal dynamo-machines and electric lamps which have been recently introduced.

SOCIETY OF TELEGRAPH ENGINEERS.—The Paper for the meeting of the 26th inst. is by Mr. Sievewright, on "South African Telegraphs."

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THE ELECTRICIAN.

TO CORRESPONDENTS.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

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AN ELECTRICAL SOCIETY WANTED.

Never since the early days of electrical discovery has there been a period when electrical phenomena have attracted so general and so keen an interest as they do at present; and never since that well-remembered time when the electric machine, the Leyden jar, and the voltaic cell were the home-made helps of every amateur, have experimenting students been so plentiful as of late. It is noticeable, moreover, that the amateur of to-day is much better educated than his predecessor, and is, at all events in practical matters, more nearly on a level with the scientific teacher. The correspondence pages of our own and similar organs afford ample evidence of the improvement to which we are referring; and there is the further undisputed fact that recent discoveries, which have been both numerous and startling, are traceable to men who make no pretensions to being professional electricians.

The question as to who are the professional electricians nowadays will be differently answered according as we put it to this school or to that. The mathematician will give a very sweeping and dogmatic answer, which is in any case sure to include himself. The telegraph engineer will urge the pre-eminence of his claims on utilitarian grounds, while the electrician whose right to the title is recognised will generally deny the pretensions of all other claimants whatsoever. We are not called upon to strike a balance between these parties, but it is plain that the field of discovery is mainly for the practical electrician. The mathematician is not necessarily, and is, indeed, rarely a practical electrician. The telegraph engineer is sometimes neither one nor the other; but an electrician, to attain to any eminence in his calling, must generally be, to some extent, mathematical, in relation to theory, as well as practical. Still, it is possible—and events have shown it to be not uncommon—for undeniable claims to the title of electrician to rest chiefly on an experimental, and hardly at all upon what we may call a scholastic basis.

It is to the class of investigators who may be termed electricians in the widest signification of the term, and also to those students who aspire to enter its ranks, that we address ourselves in the present article. We desire to call their attention to the fact that in this country they have no accredited society to represent them, and to which they can specifically attach themselves. The success which has attended this journal since its commencement only last year, the large area of its circulation, the varied character and callings of its subscribers, all point to the existence of a widespread interest in electrical subjects; and the singularly miscellaneous, not to say anomalous sources, from which we have to cull information to supply the wants of our readers, is unmistakeable proof of the want of some society of the kind we have just referred to. There is no dearth of matter, and there is no lack of publicity. But it is quite a toss-up what kind of publicity the information shall have. Ever since electricity commenced its fresh innings, its prospects have been so brilliant that every learned society has vied with every other to give it a platform. The appetite of the Royal Institution is, of course, omnivorous; and as to the Royal Society, most people are proud if any production of their's is thought dainty enough to be swallowed up there. But certain other societies, whose true vocation is special and not general, have of late so far forgotten their own particular business that it would by no means surprise us if the next new electric light were to reveal itself at the Astronomical Society, or if the latest thing in earth currents were first discussed by the Mining Engineers.

The inconveniences occasioned by this state of things are manifold and obvious. It prevents that special form of publicity which the special nature of the subject demands. For a while, no doubt, it gives a wider range of publicity than perhaps any one society could command; but its usefulness is curtailed, seeing that the audience is not the one likely to profit by it. The profession, as such, is not addressed directly; and *esprit de corps*, which counts for as much in science as in war, is distinctly discouraged. We venture to say that if some of the knotty problems which are perplexing the minds of individual electricians, professional as well as unprofessional, had had the benefit of concentrated attention such as any of the existing societies can bring to bear upon subjects properly belonging to them, a solution would have been arrived at long ago. There is no "Electrical Society" in England, and its functions can be but very inadequately

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performed, even were the other learned corporations more nearly related to it than in reality they are.

We cannot exactly be said to be behind other countries in this respect, because the electrical societies that have arisen abroad have been organised in imitation of one which formerly existed here. That society died out from natural causes, one of which was, we may surmise, that it was supposed to have fulfilled its mission. Its experimental elements found outlet in several surviving institutions—notably the Physical and the Chemical Societies—and one of its practical elements more recently in the Society of Telegraph Engineers. But that the defunct society had really not accomplished its utmost is precisely what the discoveries of recent times have made quite evident. These revelations, one may fairly assume, have been delayed, and have fallen to the lot of "outsiders" because there was no learned society for promoting the investigation in certain directions. Moreover, we are even now far from the end of the journey. We do not know all the possibly-existing means of obtaining electricity; and misgivings have arisen that neither the physicist nor the mathematician has yet furnished laws of universal application that govern its development. Theory may explain everything, but the common complaint against it is that it has created hardly anything. Indeed, it is mistrusted; and there is a growing disposition to try back again to first principles. We have not, apparently, been quite right about induction; we are still disputing, or passively differing, about conduction; and we are not by any means agreed as to what the thing we call electricity really is. There is an opening for new discovery, even among the elementary bases of electrical science, and the present time offers for their exploration a more inviting prospect than has any preceding it during the present century.

That an electrical society would greatly aid this work cannot be doubted; and in any case it would subserve some useful ends which have long been neglected. Electrical phenomena might then have a chance of being systematically investigated, and there would be a possibility of arriving at some sort of agreement as to their true signification. The existing text books are, for the most part, a chaos of incompleteness and discordance, the assumptions of many being baseless, and some of them demonstrably false.

We know that no amount of leader writing will create a Society; but it may be useful to suggest a remedy for what, in an hitherto undefined way, has, we believe, long been felt to be a pressing want. We may return to the subject again; but for the present we conclude by inviting correspondents to favour us with their views.

CORRESPONDENCE.

TELEGRAPHIC COMMUNICATION WITH THE CAPE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Much controversy has of late taken place on the subject of telegraphic communication with the cape, as to land and sea routes. We all know that such communication is much wanted at the present time, and if it is to be brought about I most distinctly maintain that the submarine route is the one which must have the preference, starting from Aden to Zanzibar, and through the Mozambique channel to Natal. If this were taken in hand at once it might be completed by the end of October next. As to the cost, I am positive it can be accomplished for less money than an aerial line through central Africa, and as for the maintenance there is no comparison. Again, Zanzibar would contribute largely to its support, and to this end the line must touch Aden, as in Zanzibar there are upwards of 8,000 Banyan merchants from Bombay and the Dutch coast, carrying on a large trade, being great speculators, and the chief supporters of the telegraphs in India. This line might touch one or more of the Comoro islands, and the Portuguese settlement. By this route we should be sure of success both as to time and stability, the coast is well-known, and for a long sea haul no better coast could be found, for a good sandy bottom may be chosen, ranging from 100 to 500 fathoms in depth the whole distance, without once losing sight of land, when once past Cape Guardafui.

With regard to a land line, you are well aware that this can be constructed; but I maintain that it cannot be done for the price mentioned; and, further, let them take what route they may, commencing at as many points as they can conveniently land stores at, they cannot possibly carry out the work under three years at least. I am well aware that Colonel Grant is an engineer, but it appears his knowledge of telegraphs and their enemies is very scant. In speaking of lines through Central Africa he only follows out statements made by others ignorant of the work and equally so of the nature of the countries where the lines have been constructed, when he brings in comparison lines through Persia to Constantinople, and those through Australia, India, &c., for there is no comparison whatever between these countries and Central Africa. As regards India, I commenced those lines under Sir W. B. Athanasy in 1853, and from that time up to 1860 I constructed and reconstructed more lines than any other engineer on the staff in India, and here we met an enemy we did not expect when we began operations, in the form of rank vegetation, such as growing crops of joaria and other grains, and wild creepers running up the poles and along the wire, thereby putting it to earth. It took us all our time the first monsoons to rectify this, and I ask, if such is the result in so short a period in India, what must be the result in Africa, where we know that vegetation is much more rank and of faster growth?

Taking the lines from Kurrachee to Constantinople: the portion from Constantinople to Bagdad was constructed by an officer and six non-commissioned officers of the Royal Artillery before either Sir Frederick Goldsmid or the late Major Patrick Steward had anything to do with the work; and it must be understood that this line only passes through three different states, viz., the Mekran, under the sway of our ally, the Khan of Kelat; through Persia, under the sole authority of the Shah; and, lastly, from the mouth of the Tigris or Shatt el Arab, through Bussorah, Bagdad, to Constantinople, under the Sultan's rule. The whole of this route I am well acquainted with, and there is no comparison in any way with this country and Central Africa, labour was abundant, &c., the country the finest for the purpose I have ever travelled over; yet, in spite of the few obstacles to be overcome, it was upwards of six years before this line was brought into good working order. And if such was the case here, with plenty of European assistance, horses, &c., at hand, what must be expected in Africa, where in a great part of the country no horse can live, and all your supervision must be on foot through dense malarious and swampy jungles?

In the case of Australia they had a free open country compared with Africa, with no unfriendly tribes to contend against, and plenty of conveyances. Wood was to hand in abundance, and the line once constructed there was little or nothing to interfere with it, and yet this line cost £160 per mile. What, I ask, would be the cost through central Africa? To hold up these countries in comparison for such an enterprise is to my mind absurd, for in the first place you have the people to contend against; every few miles there is fresh chieftainship, each petty tribe being always either at war or at enmity with its neighbour, and living in fear of one another in stockaded villages, both for protection against each other as well as from wild beasts. From the experience I have had in both South and East Africa I can endorse every word that the Rev. Horace Waller has stated in *The Times*, and it must be borne in mind that this gentleman has not only his own experience of the country, but the advantage of information derived from all the late Dr. Livingstone's papers, which he has passed, and is passing through the Press. I will defy Colonel Grant or any one else to carry a line of telegraph by either of the routes he mentions. From Pretoria to Ziti the country is quite unknown, and instead of the country from Ziti to the south end of Lake Nyassa being safe, it is at this moment one of the most unsafe parts of the whole country, the tribes for this last year have been constantly at war with each other, and from Ziti to the Mozambique coast is one of the most dense jungles with swamps and deadly fevers to contend against; and if the line from Ziti reached the coast either at Mozambique or Lindo, how is it to be brought up to Zanzibar? Not by a coast line, for this would be an impossibility, for the whole coast is nothing but swamps and rank vegetation, intersected by numerous inlets and streams forming large mangrove swamps of the most deadly kind which are overrun with hippopotami. Great engineering skill and much money must be expended in order to carry out such a line, and if constructed it could not be supervised

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and kept in working order, for in many places the wire would be stolen, the fact of its being galvanised, in itself, being a recommendation to the natives for purposes of ornamentation. The greatest enemy, however, would undoubtedly be vegetation, of the rapid growth of which I will give you some idea. In July, 1877, I commenced to construct a road for cart and waggon transport from the coast at Der es Salame in a south-west direction towards the north end of Lake Nyassa, and by the end of January, 1878, it had been completed for a distance of 28 miles; but by this time the road at the other end was quite lost from overgrowth of shrubs and rank vegetation, in spite of its having been made 20 feet wide, every root, as far as possible, having been grubbed, and the soil turned up at least 2 feet in depth, so that on going over the road in February for miles at a stretch I found weeds and rank runners from 16 to 20 feet in height. It took me, with from 30 to 40 men, two months to clear it a second time. From July to September I pushed on with the work, carrying the road a further distance of 10 miles through similar country, when I was compelled to relinquish the work, from being constantly affected with fever. My son at this time joined me, but I had to leave the work to him, and from letters just received I find that he has had to go over the road a third time; and although men have been placed on the road, each having only two miles to look after, they cannot keep it clean for transport. Now, for a telegraph line a clearance of this width must be made, what will be the expense for clearing and keeping open when made? It needs one to do more than just travel through the country to know anything of this tropical growth. The natives, in whatever part of the country you go, will steal iron in any shape if it can only be got at. During my absence from the line from Oct., 1877, to Jan., 1878, the two young men whom I left in charge lost more than half their tools, consisting of axes, hatchets, billhooks, spades, &c.; and on the 19th Sept. last the bungalow I had built at twenty-eight miles on the road was robbed of all its contents, in spite of there being two men in charge of it. Upwards of £200 of stores was stolen, and there was not a scrap of iron left of any shape or form. On my commencing work here the Sultan promised me all sorts of protection and assistance, to the extent even of 200 men as guards, if required, but such promises were not fulfilled, and when I reported the circumstance to Dr. Kirk it took him nineteen days to reply to my letter. Even then I had to work a second time, and up to the present moment no notice has been taken of the affair, and the work has been suspended in consequence. Two of the thieves I managed to capture with part of the stolen property upon them, and sent them into Der es Salame, to the Sultan's police. One of them confessed to the robbery, and stated that the party was headed by a certain chief, who at the same time confesses his guilt and defies the Sultan's authority, openly stating that if we want the property we can come and fight for it. Now, if robberies of this kind are carried on within so short a distance of Zanzibar, what may be expected further up the country? Again, there is no means of conveyance of any kind in the country but coolies, and if iron poles were used as proposed, a line of this length would require 133,500 coolies for carriage of materials, and as food is not to be purchased in many parts, you would be obliged to carry all such supplies from the coast, and as coolies for this work are not to be obtained in gangs of more than 100 at any time, I should like to know how long it would take to distribute the stores alone. It is well known that foreign labour cannot stand the climate, Take an example: I had seven Bombay men sent down from Aden, three of whom died in the first two months, and the other four I had to send back immediately, one dying before he reached the coast. Again, the Rev. N. Price brought natives from the Cape colony with bullocks, intending to reach Ujiji in four months, at a cost of £1,354 to the missionary society; the natives, however, died off or had to be sent back sick, the cattle also died, and the Rev. Mr. Price having failed in his mission returned to England, leaving it in charge of a Mr. Thompson and four others, who reached Ujiji with a small proportion of their stores in 18 months instead of four, Mr. Thompson having since died of sun stroke. Now, if it takes so many months to transport a few missionary stores a distance of 500 miles, what time will it take to transport 2,500 miles of telegraph stores; and, as Colonel Grant acknowledges that murders are constantly taking place amonst the missionaries, may it not be expected that a few telegraph clerks and assistants scattered about a great distance will fall a prey to the natives? Only last year, it will be remembered, Mr. Shergold Smith and Mr. O'Neill with most of their party were massacred at Nyanza; and, a few weeks ago only, Mr. Penrose, of the Church Missionary Society, was murdered with 63 of his porters in the Unamivesi country.

With regard to the opinion of the merchants in the Cape at Port Elizabeth and Cape Town when there in 1875 and 1876, Colony, I had a good deal of conversation with almost all at and they all advocated a submarine line, knowing as they did too well at the time how badly the lines were working through the colony. So sure as a shower of rain came, communication was stopped. I have myself observed that the mail steamer from England has arrived at Port Elizabeth before a telegram has reached by line from Cape Town, and this was not an isolated case, but occurred once at least in every third mail while I was in the colony. I noticed, too, while travelling some twelve miles out from Cape Town, that in that short distance there were 67 places where the wire was in contact with the hedges and trees. I know there are one or two fanatics in the Cape who like to be in opposition to all mankind who advocate a land line, but these are not investors, for they have not a penny to put into it, and I consider our Government will do well to weigh the matter over ere they grant a subsidy to such an undertaking as a land line through Central Africa. There are many other objections which I could show proving the impossibility of constructing and maintaining a line through such a country were it not for trespassing upon your valuable space. Apologising for the length of my letter, I remain, yours, &c.,

W. MAYES, Telegraph Engineer and Electrician.

32, Vernon-street, Northampton, March 4, 1879.

"A SIMPLE ELECTRIC PEN."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have only just seen the last few numbers of your journal, or I should before have replied to the somewhat rash assumption of M. Bellet *et Cie*. Permit me now the opportunity of stating

(1) That, amongst the 15 or 16 scientific periodicals I take, neither *La Nature* nor *Nature* is included.

(2) That I don't happen to have seen a copy of either the French or English paper (I name both, not knowing which is intended) for *several years past*.

(3) That *my* "simple electric pen" was in use some eight months ago.

(4) That the sketch which illustrated my article under the above heading was drawn by Mr. . . .* from the apparatus in the first week in November, 1878; and

(5) That the article itself was sent to the office of your journal at the same period.

As it is not worth while to make an elaborate *casus belli* out of so simple an indiscretion on the part of your correspondents, I will merely leave the few facts just enumerated as they stand, and remain, Sir, yours, &c., WENTWORTH L. SCOTT.

Bridlington Quay, March 14th, 1879.

STUDENTS' COLUMN.

The following examination paper, by a student in the School of Submarine and Military Telegraphy, George-street, Hanover-square (elementary class), may be of interest to other students. The questions which are answered are, with the exception of No. 11, correctly answered, and Mr. Kingsland obtained the highest number of marks in the examination of the class above-mentioned.

Q. 1. Define what is meant by "polarisation," and also by "local action" in a battery?

A. "Polarisation" is the electro-plating of the negative element with hydrogen, produced by the action of the battery. "Local action" is a waste of zinc element caused by impurities in the metal, which, being electro-negative to it, are acted upon by the liquid, and from small local circuits.

Q. 2. What is the joint resistance of two wires having respectively the resistance 130 and 70 ohms?

A. $R = \frac{130 \times 70}{130 + 70} = 45{\cdot}5.$

Q. 3. What is the resistance at 32° Fah. of a wire of platinum-silver alloy (sp. R = 14·93) 20 feet long and 8 mils diam.?

A. $R = r_1 \frac{l}{d^2} 9{\cdot}718 = 45{\cdot}3$ ohms.

Q. 4. A certain wire 300 feet long and 5 mils in diam. has a resistance of 700 ohms nearly. What is the specific resistance of the metal of which it is composed?

A. The specific resistance equals $\frac{R\,d^2}{l \times 9{\cdot}718} = 6.$

Q. 5. What is the resistance at 32° Fah., and also at 75° Fah.,

* The name is given for the Editor's information.

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of a wire of pure copper, 1 knot (6,087 feet) long, and weighing 1lb. avoird. (7,000 grs.)?

A. R, at 32° Fah., $= \frac{l^2}{W \times 4{\cdot}8} = 1089{\cdot}58$ ohms.

R, at 75° ,, $= 1089{\cdot}58 \times [1 + (\cdot00215 \times \overline{75-32})] = 1190$ ohms.

Q. 6. How would you arrange twelve cells, each having an internal resistance of 4 ohms, so as to obtain the maximum current, through an external resistance of 12 ohms.

A. Since the external resistance equals 12 ohms, and we require to make the battery resistance equal to this, if we put two rows of 6 cells each, and join them up in multiple arc, we shall have the internal resistance halved, because we have half the number of cells, and then halved again, because each cell is (virtually) twice the size. Therefore, $\frac{48}{4} = 12$, which is the external resistance exactly.

Q. 7. Demonstrate, by means of a diagram, the theory of the tangent galvanometer.—(*Not answered.*)

Q. 8. What work will be done in one hour by the current of five Daniells circuited through a total resistance of 100 ohms?—(*Not answered.*)

Q. 9. A mirror galvanometer, in circuit with a Latimer Clark standard cell (E = 1·457) and a resistance of 3,800 ohms, gives a deflection of 120 divisions of the scale. Through what resistance would the E.M.F. of one volt give a deflection of one division?—(*Not answered.*)

Q. 10. Required the constant for microveber current, with values in last problem.

A. $\phi = \frac{DR}{10^6 E} = \frac{120 \times 3800}{10^6 \times 1{\cdot}457} = {\cdot}31.$

Q. 11. A reflecting galvanometer, placed with its mirror at a distance of 36 ins. from the scale, is shunted with a shunt of mult. power 100, and is then circuited with a single Daniell cell through a resistance of 8,000 ohms. Under these conditions it gives a deflection of 3·25 *inches* on the scale. What is the *figure of merit* of the instrument, or the resistance through which one Daniell cell will deflect the *needle* through 1° of arc?

A. In this case $\phi = 2{\cdot}6$, and since (?)

$$R_1 = \frac{\phi \times 31{,}667{,}000}{L} = \frac{2{\cdot}6 \times 31{,}667{,}000}{36} = 2{,}287{,}061.$$

(The correct answer would be 2,069,166 ohms.)

Q. 12. A galvanometer having a resistance of 180 ohms is placed in a telegraphic circuit of high resistance, and is then traversed by a current of 260 microvebers. The instrument is afterwards shunted with a shunt of resistance 20 ohms. What will now be the current traversing the galvanometer?

A. The mult. power of the shunt is $n = \frac{200}{20} = 10$. Therefore, the current in the galvanometer equals $\frac{260}{10} = 26$.

(No note book used.)

W. KINGSLAND (Student).
DESMOND G. FITZGERALD (Examiner).

ELECTRICAL INDUCTION.

EXPERIMENTAL RESEARCHES INTO MEANS OF PREVENTING INDUCTION UPON LATERAL WIRES.*

BY PROF. D. E. HUGHES.

The induction upon lateral wires has of late years been a serious question upon telegraph lines—the constantly increasing number of wires upon the same poles, added to the adoption of high speed and consequent sensitive apparatus, renders the study of these effects of the first importance.

The disturbing effects have become each year more and more remarked, and in 1868, by the desire of the French Telegraph Administration, I undertook a series of practical experiments with the view of finding a remedy. I at once perceived that we had to deal with a question of a more complicated nature than was at first supposed. We found, then, that we had to deal with the static charge of its own line and the dynamic induction of the lateral wires; that the effects of each were very different; and whilst it was easy to deal with the comparative feeble static charge, the more powerful and rapid effects of dynamic induction could hardly be suppressed. By introducing extra resistance coils we could reduce the induced current, but at the same time we should reduce the current with which the line was working. The remedy was in most cases (particularly during faulty insulation) worse than the disease. Condensers and polarisation batteries would allow the momentary induced currents to act, whilst they prevented the more prolonged currents of the distant station. The only remedy we then found was by the introduction of an electro-magnet, with an armature fixed upon its poles—thus being a closed magnetic condenser. This practically absorbed or destroyed all the short momentary currents; but then if on this line the apparatus was working at high speed, with consequent short currents, we practically cut off the best part of the current needed.

In this case, whilst the remedy was practically perfect for an apparatus at low speed with comparative long currents, it was useless for those working at high speed requiring shorter currents, and, consequently, more sensative organs of reception.

Other duties prevented me at that date from following up this line of research. The disturbances on the lines from this cause have been on a constant increase from the adoption of more rapid, and consequently more sensitive, organs; and, in the telephone, we have at last arrived at an organ of rapidity and sensitiveness which reveals the constant induction which is the main reason why the telephone has not been more largely adopted upon telegraph lines.

In a late paper upon induction† we brought to notice the powerful organs of research in this field that we possess in the telephone and microphone; and we thought that by the aid of these we might investigate, theoretically, the cause and remedy for lateral voltaic induction.

The following experiments are a *résumé* of the results obtained:—

We made use of three separate and distinct means of research. The first consisted of two or more parallel wires, 20ft. long; the one being used as a primary was connected to battery and microphone, with clock as source of sound (both ends of wire being to earth). The secondary wire, upon which the induced current was observed, was connected to telephone—both ends of this line also being to earth.

The second arrangement was made, in order to study the effects upon a much shorter length, and with more accuracy than could easily be obtained on the longer line.

Two parallel—1 millimetre—copper wires were strung upon a board, 15in. by 15in.; these wires were placed 10in. apart, and both united at one end with one Daniell element placed near. The free ends of these wires could be put alternately in connection with battery; and thus, if we surrounded one of these wires with tinfoil, or other means of protecting wires, we could observe the degree of protection obtained, by comparing it with the unprotected wire. A difficulty was at once felt in obtaining sufficient induction upon a parallel wire of such a short length. We obviated this, however, by the construction of a flat rectangular coil of 100 turns, having 4in. side exterior. Now, by placing either of the sides of this coil near primary wire, we had 100 parallel insulated wires, of a few inches—the influence, therefore, was multiplied greatly; we had also in this coil, on the opposite side, 100 parallel layers running in a contrary direction, so the resultant strength of current was simply that due to the different distances; and it was in order to diminish this, as far as practicable, that we made the coil square. The sound obtained by this means was amply sufficient for all the researches needed.

The third means was that usually employed, namely, the use of coils either superposed or wound together in the same helix; by this means powerful effects could be easily obtained; and as the results were identical and verified by the three systems, we will at once relate the experiments with coils.

1. If we construct two flat coils of 100 yards of No. 30 copper wire each, and join one as primary to battery and microphone, the second coil as secondary, joined to telephone alone, we find that by placing one of these coils near, or within a few inches distance from the other, we hear distinctly the sounds of the clock on the microphone. Our object now being to screen the secondary coil, so as to reduce the induced current, and consequently sound obtained on telephone, we joined both coils to the same earth plate, without effect. We then took a sheet of copper, one millimetre thick, 12in. square, and placed it between the coils, without effect; joined both coils to this plate, as if it were an earth plate between the coils, but no perceptible reduction of the induced current was thus obtained. We then put 10 thin 1-32in. iron plates, 18in. square, between the coils, again joining them as earth, but still no perceptible reduction.

II. The two coils were surrounded with several layers of tinfoil, thus enclosing each separately in a continuous metallic sheath. This, however had no effect, and sounds were quite as loud, even when the sheaths were joined to earth. Placing both these metallic covered coils in a vase of salt water, and all to earth, had not the slightest effect, even when the copper plate was also interposed between the coils. Theoretically, these two

* Paper read before the Society of Telegraph Engineers.

† "Comptes Rendus de l'Académie des Sciences," Paris, December 30, 1878, and January 20, 1879.

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coils here represented a submarine cable; and as we shall see by some following experiments, neither the sea water, nor even a metallic sheath or tube around each wire would entirely prevent dynamic induction; and this has been proved in practice, as, upon a trial of the telephone between Dover and Calais, a Morse message was clearly read by Mr. Bordeaux, simply by the induced current from another wire in the same cable.

III. A single coil was made, having four separate insulated wires all wound together in the same direction. We could thus join these coils at their free ends, making several combinations each giving very different results. We will call these separate coils Nos. 1, 2, 3, and 4—the microphone remaining on primary, and telephone on secondary. No. 1 joined to microphone, No. 4 to telephone—induction strong, and consequently sounds loud and clear. Nos. 1, 2, 3, to microphone, all same direction, No. 4 to telephone—no perceptible increase of sound by the increased quantity or surface; similar results when 1, 2, to microphone, and 3, to 4, to telephone.

Thus by no combination of parallel wires can we hope to diminish induction; but if we join Nos. 1 and 2 to microphone, so that the current from 1 returns by 2, then we have a complete screen—no sound whatever being now heard on the secondary coil No. 4. The same effect takes place if we join 1, alone, to microphone, and 3 returning by 4 to telephone. Consequently, if a telegraph line or a telephone line had a return wire upon same poles, and absolutely equidistant from the inducing wire, we should have perfect protection, from the fact that the primary would then induce parallel currents in both wires in the same direction, but, contrary to itself, and these parallel currents would, being of equal force, neutralise each other. The remedy here is complete, although it is true that it would introduce a double resistance, and the cost of a double wire cable would probably prevent its use. Leaving, however, the practical objections to its use aside, we shall see by some following experiments that the remedy as regards prevention is absolute.

IV. Taking the same 4-wire coil, and joining 1, 2, and 3 to microphone, so that current goes through 1, returns by 2, and back again by 3, we then hear on No. 4 only one half the induction that would be caused by either wire alone.

V. Using still the same 4-wire coil, and sending by 1 and returning by 2, no sounds are heard as we have already shown, but if we short circuit either 1 or 2 we at once hear strongly the sounds induced by the coil that is not short circuited, in this case without interrupting the flow of the current or breaking the communications. We have produced or annulled an induced current merely by cutting off its protecting contrary direction coil, and if the microphone instead of being placed in the direct primary circuit is placed between the junction of 1 and 2, and either coil, we hear the sounds not by any variation in the primary circuit, but simply by the more or less protective influence of the return wire.

VI. If instead of a return of wire of same length in this four-wire coil we use a shorter wire in same coil, it does not protect it, except for the same length as the protective wire; and if as return we use an exterior coil at some distance apart, but of same length as primary, it does not protect it at all; this is evident, as from theoretical considerations we know that the return wire must be equidistant, and should be of equal length and diameter.

VII. Knowing that a metallic envelope diminishes in a slight degree the induction—first, by the work done in inducing parallel currents in this wire itself when on a closed circuit, and, secondly, by the consequent diminution of force after such work—we tried how the many similar closed coils, introduced between the primary and secondary, would reduce the amount of induction to one quarter of its original amount. The primary and secondary being placed 6in. apart, the introduction of one or two similar coils between them gave no perceptible reduction of force, and it required twelve such coils to reduce the induction to one-quarter of the original amount, and this reduction only took place if the interposed coils had closed circuits; the instant the circuits were opened there was no perceptible difference with or without the twelve interposed coils. From this we draw the conclusion that the only reduction takes place when work is done in interposed coils by being on a closed circuit, and that it would require a tube of metal to surround a conductor at least twelve times the amount of primary wire, in order to reduce its inductive effects to the one quarter as above stated.

VIII. The results obtained with coils were now applied to two lateral wires in a straight line 20ft. long—the primary being insulated by gutta percha, and covered externally with tin-foil several times. Here we had the exact conditions which have been more than once proposed as a remedy or prevention of induction for the use of telephone lines. This covering, however, was found to be no protection at all, the induction was equally as strong with exterior coating to earth or open—theoretically there should have been a slight, and, as we have already seen, *very* slight reduction, but the difference was not perceptible. The induction through this protective covering gave loud sounds on telephone, but if we used the outer tin-foil covering instead of a return wire for primary, then no sounds at all were heard; in fact, it formed a perfect protection, as we have already seen, in the four-wire coil.

IX. The short local wire of 15in. already spoken of as the "second arrangement," was now used. The primary wire was led through a glass tube 12in. long, which had ten coverings of tin-foil, all joined to earth. This arrangement proved, as above stated, of no avail; the current, however, being returned by tin-foil covering proved a perfect protection. In addition to the ten tin-foil coatings we added 20 coatings or cylinders of thin charcoal iron—making an exterior diameter of 4in., and a total thickness of metallic sheath of ¼in. between primary and secondary wire. As but little reduction was perceptible, we placed a magnetic needle, suspended by a silk thread, at a distance of 4in. from the primary, and measured the deflection by current. Without any protective coating it gave 3 deg. deflection, with glass tube and ten tin-foils to earth 3 deg., with the additional twenty iron cylinders about 2½ deg.; thus the magnetic lines of the voltaic current pass easily through non-magnetic and magnetic bodies, and as the dynamo induction is due to the change in this field of force, it is easy to see why the numerous metallic sheaths failed to arrest the inductive force.

We have seen by the preceding experiments that we should have perfect freedom from induction if we employed a return wire at equal distances from the inductive wire, and instead of a metallic sheath, as we have seen might serve, it would be best to employ two separate gutta percha or insulated wires, and in order that each wire should have absolute equal effect, a slight twist of these two wires should be given, this twist would then successively bring each portion under equal influences.

Since making these experiments we have learnt that Mr. David Brooks, of Philadelphia, first suggested a twisted double wire as above described as a preventive against induction, and that it has also lately been patented by Professor Bell.

A more perfect solution of this question than that of using a double wire with one as a return, giving double resistance to that of an ordinary wire, would be to use a double wire having a slight twist, each wire acting as an independent line with its own earth at each station, and its own separate battery at transmitting station. The transmitting instrument should be so arranged as to send simultaneously positive in one line and negative in the other—these if of equal force would exactly balance each other as regards induction on other lines. The receiving electro-magnet should be wound differentially, or, what would be still better, should have two separate wires wound together. The external end of one of these wires should be to one line, and the internal end to earth; the other wire should, on the contrary, have its internal extremity to the other line and its external extremity to earth.

The effect of this would be that if any current of same direction passed both wires at the same instant no effect whatever would be felt on the balanced electro-magnet, but if two currents, each of opposite direction, passed through the coils or electro-magnet, then it would work at its maximum effect; we should thus have a double wire line with less resistance than the single wire, with complete freedom from earth currents, dynamo induction, and from all extraneous disturbing causes.

If two ordinary aerial lines are thus used, they should have the twist given to these wires by changing their position relatively to other wires from vertical to horizontal, and *vice versâ*, at each pole or mile; thus if we had two lines, A and B, they should have these four relative positions repeated as often as possible, viz.: A B, then $\frac{B}{A}$ then B A, and $\frac{A}{B}$.

We have tried to find a theoretical remedy by means of which a single wire would be free from this disturbing influence, and we have found that there is no possibility of a perfect solution of this question, provided that we send and receive on alternate wires at the same end; but if all the wires send in one direction during a stated period only, or work constantly in one direction only with one set of poles, receiving by another route or set of poles, then the resolution of this question becomes not only theoretically possible, but, I believe, practically so, provided the lines are, as in France, all arranged in one plane, or nearly so—the only departure from the vertical plane consisting in the wires being alternately strung on each side of the poles; and this is perfectly followed by the compensating instrument which I have the honour to present this evening for the first time to public notice.

Suppose three or more parallel lines, A, B, and C; now, A induces a current on B and C proportional to its force of battery power and the several distances of these wires from the inducing

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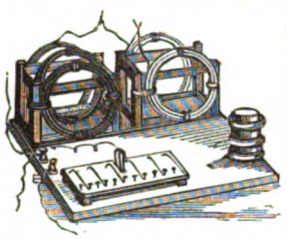
wire. If we can send into the wires B and C an opposing current of exactly equal strength and duration to that of the induced current, we evidently reduce the induced current to zero, and have consequently no disturbing effects on those wires.

After numerous experiments, I have found that if coils of wire be so placed in relation to each other, that their relative distance represents the relative distance of the wires from each other, and if each line at its transmitting station be joined to earth through these coils, then in passing the battery current through one of these coils to its line, it would induce a current whose direction would be contrary to itself; and as this would be exactly what takes place on the line itself, we should (supposing the coils to have equal inductive force to the lines) simply double the induced current, and the disturbing effects would be twice as much as what they were before the use of the coils; but if at the same instant that we send battery on line we reverse the terminals of the coil in relation with it, then the induced current sent by coil will be in the same direction as battery on primary, and this would neutralise the contrary direction of the induced current, reducing it to an absolute zero.

I have embodied this idea in the instrument which I present this evening, consisting of a series of coils of insulated iron wire. There are two of such coils, 10 centimetres diameter, 100 metres long, connected together so as to form a single line; these are placed at a distance of 10 centimetres from two similar coils, and between them, at the distance of five centimetres, is a single coil. We have thus two long lines and one intermediate short one. The induction of these coils on each other represents the induction on similar iron aerial wires; the effects, however, are much greater with coils than on straight wires, and this fact allows us to reproduce with a hundred metres of wire only the full amount of induction on a line of a hundred miles or more. The reason of having a shorter intermediary coil is, that it represents, as we have found, the most difficult portion of the problem.



To compensate for the induction on these lines, we have three small No. 32 copper (covered) coils; these are so arranged on a graduating scale that they can be gradually approached until the exact balance for each line is found; and this is found very rapidly, for we have only to slide it until complete silence is obtained from the induced currents passing other wires. These coils have no necessary absolute relation as to length or power to that of line, as we can increase the force by approaching them; but in the case of intermediary wires, and also several wires of same or unequal length, the coils should bear a definite ratio to the length of the line, say 100 metres of copper coil to 100 miles of line; but, from the powerful effects I obtain with the coils I have experimented with, I believe that 100 metres per 500 miles of line would be amply sufficient.

Each coil should be reversed by the key of the instrument at the instant of putting on the battery, and with these conditions the compensation is most perfect, and lines that were full of powerful induced currents all become perfectly free from it, whilst it in no way militates against the transmission of the battery current on its own line. But as our object this evening is not to bring forward new instruments but to discuss the question generally, we will at once sum up our conclusions.

There are three points on ordinary telegraph line or lines where we may attempt a solution of the difficulty by compensation or other neutralising effects, namely—receiving, intermediate, and transmitting stations.

At the receiving station, ordinary induction coils, or the compensating coils I have described, would be injurious, as they could not be reversed in relation to each other, and would thus increase the induction.

Voltaic currents, direct or by derivations from primary line, would answer only where the signal consisted of a dot or a short signal exactly equal in duration and force to that of the induced current.

Polarisation batteries, direct on line, would allow the induced current to pass, and if used as a derivation would require a very great resistance, and would allow the extra current from the working electro-magnet to affect all the rest.

Condensers would be similar to the polarisation or secondary batteries. Resistance coils would reduce the induction, but also in equal proportion reduce the voltaic current needed. Magnetic condensers would absorb the induction, but also absorb the first part or the part most needed of the voltaic current.

At the intermediate station all these would give contrary effects to those desired, except secondary batteries and condensers in derivation; but these would weaken the primary current, and for a line of ten wires would, from a calculation we have made, require 45 such condensers, and even then it would be impossible to fulfil all the necessary requirements.

At the transmitting station ordinary induction coils could not be used except for a line of two wires only.

Derivations from sending battery would require that a great resistance between line and earth should be introduced, and, moreover, the current would be prolonged beyond the induced current.

Polarisation batteries and condensers would also, if in derivation, require great earth resistance, and would require for a 10 wire line the same number of condensers as the intermediate station with like results.

Compensating coils, as arranged in the instrument we have submitted, fully meet the difficulty, giving perfect compensation for any number of wires, with but one coil to each wire, provided that the lines are used for transmission in one direction only for stated periods, and that they are arranged as in France, as already explained.

The perfect line, however, itself quite free from induction, and not inducing on other wires, and therefore requiring no compensating arrangement, is the double wire we have already mentioned, where both ends are to earth, and its electro-magnet wound differentially.

I have studied this subject with much interest because I believe that the future improvement in telegraphy depends in a great measure on its entire solution, and I hope that by a discussion on this subject new facts may be brought to light.

COMPANHIA TELEGRAPHICA PLATINO BRASILEIRA.

The adjourned general meeting of the above Company was held on Friday, the 14th inst., at the offices, No. 66, Old Broad-street, under the presidency of Mr. John Pender, M.P.

Mr. W. PAYTON, the Secretary, having read the notice calling the meeting, read the minutes of the last meeting, which were approved by the present meeting, and signed as correct by the Chairman.

The CHAIRMAN then reminded the meeting that the object of the adjournment on the former occasion was to receive a report from the Committee appointed to report on the Directors' report. That was in accordance he believed with Brazilian law, and the constitution and Articles of Association of the Company. It was most difficult to work the Company as it was now constituted.

The SECRETARY then read the report of the fiscal committee—Sir James Anderson, and Messrs. J. Beaton and C. Burt—who stated *inter alia*, that the arrangement mentioned in the report of the last fiscal committee as being made with Messrs Grant to put an end to the litigation which was pending between them and Messrs. Hickie, Borman and Co., as agents for the Company, was carried out by an order of the court in the action, by which the accounts were referred to the arbitration of Mr. Turquand, and the investigation before him was still pending when the failure of Mr. Grant took place, and had not since been continued. They were informed by the accountants that all expenses previous to June, 1874 (about which date the Company commenced to earn revenue) had been charged to capital account. Since that date all expenses had been charged to revenue, except such as were clearly chargeable to capital. They approved this arrangement. When the statutes were originally framed the issue of part of the capital in the form of debentures did not appear to have been contemplated, and it was doubtless anticipated that the profits of the Company would be far larger than they have been. The Brazilian directors did not during their period of office set aside any part of the profits for the reserve fund, and, therefore, it appeared to them that the course adopted by the present directors in setting aside for the reserve fund 10 per cent. of the net earnings of the Company from its foundation, before deducting interest on the debentures, was right and prudent. They had asked the accountants for the details of the large item of £18,378 for general expenses from the 30th June, 1874, to the 31st December, 1878, and they were informed that £2,654 only of this amount had been incurred by the present directors of the Company (when acting as the committee of shareholders and during the last six months), the whole of the remainder having been incurred during the management of the Company in Brazil. They learned from a circular issued by the Western and Brazilian Telegraph Company to its shareholders that the telegraph line from Para to Monte Video (including the new lines into Maranham) was for the first time in complete working order throughout, also that during the last twelve months 830 miles of new cable, nearly all sheathed, had been relaid in shallow waters, leaving but a moderate length in these waters which it would be necessary hereafter to renew, and that the old cable laid in deep water was in excellent condition. Having regard to the participation of the Company in the gross receipts of the Western and Brazilian Company, this information was of great importance. The accountants had, at their request, prepared an estimate of the future profits of the Company, based on the income of the last year, showing a probable net income of £7,800, after setting aside the reserve required by the Articles and paying the interest on debentures. This estimate appeared to them to be a very moderate one. They recommended that the Directors' report should be adopted, and that the dividend proposed by them should be declared and paid.

Mr. BEATON here entered the meeting, and in reply to the Chairman (who stated that the Bazilian law required that the report of the fiscal committee should be read by one of its members) said he considered the report as having been read by himself.

The CHAIRMAN then moved—"That the report of the fiscal committee be approved, and that a dividend of 5s. per share, free of income tax, be declared and paid."

Captain PAVY having seconded the motion, it was carried unanimously.

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The CHAIRMAN, in reply to questions, said the £7,800 mentioned in the fiscal committee's report would give about 2 per cent. on the capital of the Company. The £7,800 was merely an estimate, and he believed a very low one—it was supposed to be the minimum. The £300 which the fiscal committee recommended should be paid to the gentlemen who acted as the shareholders' committee from June, 1877, to May, 1878, was a total sum, to be distributed amongst members of that committee. They started that day with a 5s. dividend, and they hoped from that day forward it would be continued. The resolution was then unanimously passed, after which the Chairman, continuing, said he desired to make a few remarks. As they were aware, the success of the Company depended in a great measure on the success of the Western and Brazilian Telegraph Company. That company had passed through a great deal of trouble, but he thought they were getting their system into a very much better state than at any period in their history, and he was very confident, from knowing something of the men who were now at the head of that company, and of the management generally, that they (this Company) might expect very much better results than they had hitherto had. The Western and Brazilian Company now occupied a sounder and firmer position than at any previous period, and this Company would share in that company's general prosperity; and, looking to the development of telegraph property, although the fiscal committee had taken a very low estimate, he thought there was a much better prospect for this Company than at any previous time. Again, when the Company was in Mr. Grant's hands, no one knew what was being done; but now it was virtually in the hands of the shareholders, and they would know exactly how it was being managed, and the prosperity attending it. As to the transfer of the Company to London, he would request the Secretary to read a letter they had received on the subject from their solicitors, and he thought this was another step in the right direction.

The SECRETARY having read the letter,

The CHAIRMAN, continuing, said they had instructed their solicitors to carry out without delay the constitution of the English Company, and the bringing to London of the whole of the business of the Company. To facilitate that they had about one-half of the foreign shares, and they were in such a position that there would be no difficulty on this point. They had received a report from Mr. Oldham, who was connected with the Western and Brazilian Telegraph Company, and, with the permission of his Board, they had asked him to go over the land lines, carefully inspect them, and report on them. The report was very exhaustive indeed. It was a system embracing 518 miles of land lines, which was a very considerable portion, and he thought the report was a favourable one. The line was in good working order, and very little was required to put it in first-rate order. The traffic was not as large as one would like to see, but in those parts he believed they carried telegraph lines into parts where we should never think of going in this country; and the consequence was that there was a good deal that was not productive. At the same time, the amount of traffic altogether was such as to pay expenses and a little more, the Government messages being to the good. But the Government, with every desire to encourage the telegraphic system—and they used it a good deal—were not very prompt payers. They, however, hoped in the future to see a little more of the money of the Government than they had seen in the past. He had received a letter from General La Torre, and from information he had from other sources, he believed that the General was a man of great ability and energy, and, what was, perhaps, more valuable still out there, he was esteemed a man of high honour and honesty. With such a man, if allowed to retain the position he now occupied, viz., President of the Republic of Uruguay, he thought there was a better future for the country, and with an improved trade there would naturally be an improved traffic. The letter from General La Torre to himself was in the most friendly spirit, and he intended to reply, stating that they were most anxious to promote the good of the country, and that so far as their telegraphs were concerned they would maintain them in efficient order, but that they could only do that if the Government promptly paid what they owed the Company. They used it very freely, and he hoped they would pay them in such a way as to enable them to maintain its efficiency. Altogether, although their dividend was small, it was better than nothing, and he thought the prospect was that it would be an improving dividend. At all events, he might say, with perfect confidence, that it had now come into hands—or was about to—of people who felt their responsibility, and they would endeavour to carry it out in such a way as would meet with the approval of the shareholders [applause].

Major WOOD, the manager of the Western and Brazilian Telegraph Company, said that since the opening of that company's lines into Maranham, its revenue had shown an increase at the rate of £20,000 per annum, so he thought that this Company would have another £5,000 beyond the £7,800 referred to. The shareholders were to be congratulated on the results already attained by the Board.

Mr. SANDERSON alluded to the importance of a reserve fund, and said that they must all bear testimony to the honesty and ability of Mr. Rawson, the chairman of the Western and Brazilian Telegraph Company.

The CHAIRMAN said, with regard to the prospect held out by Major Wood of an additional £5,000, he thought it was far better that they should be agreeably than disagreeably disappointed. With a good reserve fund they could stand much better against opposition or any other adverse circumstance. There was another reason why they should have a reserve. Their cable, it was true, was to be maintained by the Western and Brazilian Company, but they had £100,000 of debentures, and the accumulation of a reserve fund would be very handy when the debentures fell due if there should be any difficulty in renewing them, and every shilling they added to their reserve increased the security and stability of the Company. Their policy was to put the Company's affairs in as sound a position as they possibly could. The dividend would be paid immediately.

Mr. SANDERSON eulogised the candid and straightforward statement of the Chairman, and moved the best thanks of the meeting to the Chairman and Directors for having placed the Company in its present position.

Major WOOD seconded the motion, which was carried enthusiastically.

The CHAIRMAN, in reply, after expressing his obligations, said he could assure them that from the beginning he had always looked upon submarine telegraphy—in fact, general telegraphic enterprise—as one of the leading characteristics of the age—an institution which was likely to do a greater amount of good than any other they had seen brought forward, even in these remarkable days of progress. Now that their Company had come—or was about to come—in what he called the circle of well-to-do telegraphic systems, he hoped they would have no drawbacks in future, and that they would go on steadily progressing, as the circumstances of the country allowed them. He did not expect their progress would be very rapid, but even in these Republics he believed they would get tired of revolutions, and every day of peace in all those places was, they might say, a day of profit.

The proceedings then terminated.

MONTEVIDEAN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).

The annual general meeting of the shareholders in the above undertaking was held on Monday, the 17th inst., at the offices, King's Arms-yard, Moorgate-street.

Sir THOMAS GORE BROWNE, K.C.M.G., C.B., presided, and moved the adoption of the report for the year ending the 31st of December last, stating that the Company's percentage of the gross earnings of the Western and Brazilian Company amounted for the year to £3,295, the December quarter being estimated at £750. This total included a sum of £432 10s., which the Western and Brazilian Company claim to deduct as the proportion chargeable to this Company of the cost of carrying messages overland, whilst portions of their cable were under repair. Adding to the earnings the balance of £660 brought forward from last year, the revenue account showed a gross credit of £3,956. After setting aside £500 for redeeming debentures, and providing for all charges and debenture interest accruing during the year, there remained a net balance of £1,914, out of which it was proposed to pay a dividend of 3s. per share, being at the rate of 1½ per cent. per annum, and to carry forward a balance of £667 to the next account. This balance included the £432 10s. claimed by the Western and Brazilian Company. They anticipated an increase of revenue this year, as they had recently received a communication from the Western and Brazilian Company, to the effect that "telegraph communication has been completed from Para to Montevideo," and that "this places the Company's entire system, including the new line into Maranham, for the first time in complete working order," also that "the cables are now working from Para to Montevideo, including all the intermediate ports required by their concession." He moved the adoption of the report.

The resolution having been seconded, it was passed. The retiring director, Mr. Charles Cameron, M.P., was re-elected, as was also Mr. W. S. Ogle, the auditor. The proceedings then terminated.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).

Abstract of Report of the directors to be presented at the general meeting of shareholders to be held on Monday, the 31st March, 1879. The accounts for the half year ending 31st December, 1878, show a balance to the credit of profit and loss of £3,588 0s. 6d. The traffic receipts for the half year are £729 5s. 2d. in excess of those for the preceding half year, and £694 15s. 11d. in excess of those for the corresponding period of 1877. The result attained may be considered fairly satisfactory in presence of the depression affecting all classes of business. The slight revival in the iron trade in the North of Spain, apparent at the end of last half year, was of very short duration. The cables of the Company continue to work perfectly, and their electrical condition is reported by the Consulting Electrician to be as high as ever. By the adoption of improved instruments a high rate of speed is attained upon the Bilbao Cable with the Morse system, and direct communication between England and Madrid rendered practicable. After providing for the half-yearly dividend on the preference shares at the rate of 10 per cent. per annum, which it is proposed to pay on the 1st April, there will remain £666 10s. 6d., of which the directors recommend that £623 9s. 3d. be placed to the reserve fund, which will then amount to £1,700, leaving a balance of £43 1s. 3d. to be carried forward.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES MARCH 19.		BUSINESS DONE WEEK ENDING MARCH 19. Highest.		Lowest.	
Anglo-American	57,	¼	57¼		57	
Do. "B"	85½,	¾	86½		86¼	
Do. "A"	28½,	29½	29¼		28¼	
Brazilian	6 13-16,	15-16	6 15-16		6 13-16	
Cuba	8,	¼	—		—	
Do. Ten per Cent. Preference	15,	½	15½		—	
Direct Spanish	1¼,	2	—		—	
Do. Ten per Cent. Preference	10¼,	11¼	10¼		—	
Direct United States	11¼,	¾	11¾		11¼	
Eastern	7 5-16,	7-16	7 7-16		7 5-16	
Do. Six per Cent. Debenture	104,	107	—		—	
Do. Five per Cent. do.	100,	102	—		—	
Do. Six per Cent. Preference	11¼,	¾	11¾		11¾	
Eastern Extension	7 5-16,	7-16	7 7-16		7 5-16	
Do. Six per Cent. Debenture	104,	107	—		—	
German Union	7¾,	8¼	—		—	
Globe Telegraph and Trust	4¾,	5	5		4 15-16	
Do. Six per Cent. Preference	10 5-16,	7-16	10½		10¼	
Great Northern	8,	¼	8¼		—	
Indo-European	21,	22	—		—	
Mediterranean Extension	2¾,	3¼	—		—	
Do. Eight per Cent. Preference	9¼,	¾	9¾		—	
Reuter's	9½,	10½	—		—	
Submarine	215,	225	—		—	
West India and Panama	1½,	2	2		1¾	
Do. Six per Cent. Preference	8¼,	¾	8 11-16		8¼	
Western and Brazilian	4¼,	¼	4 5-16		—	
West. Union Seven per Cent. 1st Mort.	114,	118	—		—	
Do. Six per Cent. Sterling	100,	102	—		—	

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NOTES.

REGISTERING ELECTROMETER.—M. Mascart has invented a mechanical register to accompany Sir W. Thomson's quadrant-electrometer, which will enable the variations of atmospheric electricity and terrestrial magnetism to be easily recorded.

GALLIUM.—M. Reynauld has been experimenting with a battery made of liquid and solid gallium, by means of a metal solution of gallium sulphide. The liquid takes the place of the zinc in ordinary cells, the solid of the copper, the former being electro-negative to the latter.

QUADRUPLEX TELEGRAPHY IN INDIA.—According to the *Madras Times*, the experiments in which Mr. R. S. Brough, the electrician of the Indian Government Telegraph Department, has recently been engaged with Edison's patent for working the quadruplex, are said to have unfortunately resulted in failure.

GREAT NORTHERN TELEGRAPH COMPANY.—At the general meeting, to be held at Copenhagen on the 16th April next, it will be proposed that a final dividend of 2s. 9d. per share be declared, thus including the five per cent. interim dividends already paid, making the total dividend for 1878 $6\frac{3}{8}$ per cent. It will further be proposed to add £44,444 8s. 10d. to the reserve fund, which will then, after the year's outgoings, stand at £91,999 13. 2d., and finally that £14,837 0s. 11d. be carried forward to next account.

ELECTROPHONE.—M. Ader uses a kind of drum, having in one side a diaphragm of parchment paper, about 5·9in. in diameter, in the centre of which, and circularly arranged, are six pieces of tinned iron, 37in. long and ·079in. wide. On these act six extremely small electro-magnets, connected to and set in action by a carbon microphone. Three Leclanché elements are used. Words and music are heard at 16·5ft. from the instrument. The effect is due to the small magnets, which are more rapidly magnetised and demagnetised than large ones.

LOADSTONE AND STEEL.—Dr. Holz, in his experiments upon natural and artificial magnetism, concludes that (1) the maximum of permanent magnetism in the loadstone, for equal volumes, is about the same as that in the hard steel; (2) the specific magnetism of the loadstone is the greatest of all magnetic bodies yet investigated; (3) the permanent magnetism of the loadstone is sooner reached than that of steel; and (4) the quantity of temporary magnetism which disappears after the magnetising force is removed, is less in the loadstone than in steel.

ELECTRICITY IN LIGHTHOUSES.—On Tuesday, 26th March, a paper on this subject, by Mr. J. Douglas, was read before the Institution of Civil Engineers. The paper was almost wholly historical, and contained a mass of valuable information. It shows that from the first introduction of electricity for lighthouse illumination there has been a constant and very large diminution in the cost of the illuminant, and at the same time a great increase in its effectiveness. Communications were read from Mr. J. Stephenson and Prof. Tyndall on the subject of the paper, and the discussion is to be continued at the adjourned meeting next Tuesday.

ELECTRIC LIGHT.—The Select Committee of the House of Commons appointed to inquire into the subject of the lighting of towns by means of electricity, and to which the Liverpool Lighting Bill was referred, has determined to go into the general question, settle the principle, and then leave the thirty-four private Bills which ask for powers to light by electricity to be dealt with by the regular Committees of the House of Commons. The inquiry will commence on the 31st inst. As the evidence will be lengthy, and the committee will probably report late in the Session, it is expected that no powers will be granted this Session for lighting by electricity.

A NEW CONDUCTOR.—Mr. Alberger has patented in America a novel kind of conductor, consisting preferably of a decarbonised steel wire, surrounded by a vitreous substance, over which is placed a metallic tube. To manufacture this conductor, the inventor produces a glass bulb at the end of a glass blower's tube, and passes a wire into the bulb, then drawing wire and bulb forward he obtains a conducting thread covered with glass. The wire with its casing is put into a wrought iron tube, and the whole heated to a welding heat, and reduced in size by rolling. Joints are made by an ordinary screw coupling, the ends being first rounded off by an emery wheel, to render a contact of the conducting wire certain. This way of making a joint may seem pretty, but we very much doubt its practical success. A conductor thus made is according to the inventor protected from oxidation and is completely insulated. The weak point in the whole seems to be the "joint."

A TELEGRAPH TO THE CAPE.—The three tenders sent in to the Government for a cable to establish telegraphic communication with Natal are substantially as follows:—One tender offers to make and lay a cable by either of the routes indicated, the Government to supply the funds for doing so. A second tender offers to make and lay a cable from Natal, *viâ* Mauritius and Seychelles Island to Cape Comorin, forming a connection there with the Indo-European system. All messages over this line would, in their overland transmission, pass through Turkish, and in some cases Russian, hands. The third tender comprises the offer originally made by the Eastern Telegraph and the Telegraph Construction and Maintenance Companies as follows:—To lay a cable already made between Natal, *viâ* Delagoa Bay, Mozambique, and Zanzibar to Aden, connecting with the system of the Eastern Telegraph Company. Duplicate cables are in existence in this system from Aden to England, excepting between Gibraltar and Lisbon. In case of interruption between these points the Eastern Telegraph Company can use their private wire across Europe through France. This tender takes all the risk of laying the cable, and asks a guarantee, said to be 5 per cent., for twenty years, less similar subsidies offered by the Cape and Mozambique Governments and the Isle of Bourbon. The total cost would be about £1,100,000.

STUDIES IN ACOUSTICS.—Mr. W. H. Preece and A. Stroh presented a paper on this subject recently to the Royal Society. The investigation has little connection with electrical matters, except indirectly. The authors of this paper have devoted much time during the past twelve months to a

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study of sonorous vibrations and the reproduction of speech. The curves traced by the vibrating discs of the phonograph on tinfoil, whether examined microscopically or reproduced by a species of pantelograph, were soon found to be insufficiently delicate to give the nicer shades of sound, and to fail to indicate the true curve of vibrations in all cases. This is shown by the imperfect reproduction of speech by the phonograph itself, the merging of the labial and dental sounds into one another, and the absence of all the sibilants and generally of the "noises" of speech. The phonograph is in reality a very imperfect speaker, and it requires the aid of much imagination and considerable guessing to follow its reproductions. It produces music with wonderful perfection, but it fails to reproduce most of the "noises" of which speech is so largely made up. The telephone is also deficient in this respect, though to a much less degree. The first object of the authors was to find a disc which would vibrate to the finest shades of sonorous vibrations, and which would be free from those characteristic and "personal" partials which are nearly inseparable from all vibrating discs, and which interfere with their true action. A stretched membrane of thin india-rubber rendered rigid by a cone of paper, was found to give the best effects. Such a disc was applied to the telephone and the phonograph with fair results. To the centre of the cone, which was placed in a mouthpiece similar to a phonograph, was attached an extremely fine glass tube which acted as a pen. The ink employed was aniline dye, and it was drawn through the pen by the very slight friction exerted between its point and the paper. The paper on which the curves were to be drawn was the broad band frequently used for telegraphic purposes, and it was drawn under the pen by mechanicism similar to that used in the Wheatstone automatic telegraphic apparatus, at a speed which could be varied at will from 1 to 18 inches per second. In this way curves were obtained illustrating the sonorous vibrations due to the tones of speech, but their form was not so perfect as could have been wished, owing to the imperfections of the disc, as well as, perhaps, to the friction of the pen failing to indicate the higher upper partials. Run at a slow speed, this instrument records the variations of air pressure in front of the lips; run at a high speed it records both air pressure and sonorous vibrations. Helmholtz's theory of vowel sounds was explained, and the investigations of Fleeming Jenkin and Ewing referred to. The manner in which vowel sounds blend into each other is strikingly shown in the way in which different dialects deal with different vowels. Thus, what a London man calls *subject* a Lancashire man calls *soobject;* a Londoner says *Măn-chester*, a Lancashire man *Mawnchester*, a Scotchman *Mon-chester*. *Under* is often pronounced *ŏnder*. We need not, however, examine different dialects to discover this curious blending of vowel sounds; it is found in inhabitants of the same district to a greater or less extent. Thus with the word *Manchester*, Londoners often say *Menchester*, *Manchester*, or *Marnchester*. In every case which the authors have investigated this change of vowel sound, due to dialect, is simply due to the shifting or lowering of the upper partials. In this investigation the question has been attacked by the method of synthesis. It has been assumed that vowels are compounded of a prime sound and certain upper partials, and the number of these partials has, for convenience, been taken as 8, although there are many more. Indeed, we have taken in some cases, the 10th, 12th, and 16th. Now, since each partial can be considered as a simple harmonic curve, if we assume the pitch of a prime to be constant, then it would be possible, by means of a machine, to represent and vary each partial in phase and in amplitude. For this purpose an instrument was constructed, which we call "the synthetic curve machine." Besides assuming the pitch to be constant, it has also been assumed that each octave of the partial, to maintain equal loudness of sound, must diminish one half in amplitude as it rises. The intermediate notes, such as the third and fifth, decrease in intermediate ratio. This instrument enables us to form synthetically all the curves produced by vowel tones, and to show how these tones are compounded of primes and harmonic upper partials. It shows how *simple tones* can be produced by simple harmonic curves, and *compound tones* by the simultaneous action of several simple tones. Having thus studied the formation of vowel sounds, and having a means to reproduce the compound curves which graphically represent the motions which the air particles assume under their influence, the authors determined to try to reproduce these vowels by superimposing partials on to a given prime. Since vowels are produced by a prime and its upper partials, and as the upper partials diminish so rapidly in amplitude, the idea arose that these vowels might be reproduced by sounding a prime and one of its partials alone. This was done by means of an electro-magnet vibrating an armature with a moveable spring attached to it in such a way that the vibrations of the armature could produce a given prime, while the vibrations of the spring, by varying its length, could also be adjusted to any particular partial. The result was to roughly reproduce the principal vowel sounds, but the effect not being by any means perfect (owing to the absence of the other upper partials), a machine was made on the principle of the synthetic curve machine, which would, instead of drawing curves on paper, reproduce eight partials by transferring the vibrations of the intermediate wheels to a vibrating diaphragm. Thus, notes and chords can be sounded. Here, again, though the vowels were fairly reproduced, something was wanting in their clearness. In the hope of getting more perfect definition, another machine was now made upon which discs were fitted, whose peripheries were cut in exact copy of the curve produced by the synthetic curve machine. These curves were transmitted by vibration to the receiving diaphragm of a phonograph, and really formed an "automatic phonograph." One very curious result arising from the experiments with the automatic phonograph was to show that, by varying the pitch, the vowel sounds could be shifted, *i.e.*, the curve which produced *oo* at a low velocity becomes approximately at *O* a higher velocity. *O* similarly becomes *ah*, *ah* becomes *ā*, and *ā*, *ēē*. It follows from this investigation, as far as it has gone, that our knowledge of vowel sounds is not perfect. The principal proof of this is the fact that vowels cannot be reproduced exactly by mechanical means. Something is always missing—probably the noises due to the rush of air through the teeth, and against the tongue and lips. The curves, arrived at synthetically, do not differ very materially from those arrived at analytically by Helmholtz. They principally differ in the prominence of the prime. But the prime can be dispensed with altogether. Curves produced by the synthetic machine, compounded of the different partials without their prime, show that there exist *beats* or resultant sounds. Another point remaining for investigation arising out of this inquiry is the true theory of the loudness of sound. It is thought by the authors that loudness does not depend upon amplitude of vibration only, but also upon the quantity of air put into vibration; and, therefore, there exists an absolutely physical unit in acoustics analogous to the unit of quantity of electricity or quantity of heat, and which may be called the quantity of sound.

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FOUR LECTURES ON ELECTROSTATIC INDUCTION.

JAN. 16, 23, 30, AND FEB. 6.

BY J. E. H. GORDON, B.A.

(Assistant Secretary of the British Association).*

LECTURE IV. (CONCLUDED FROM PAGE 208.)—FEB. 6.

SPECIFIC INDUCTIVE CAPACITY OF GASES.—ELECTRO-MAGNETIC THEORY OF LIGHT.

Now comes the question, What properties common to both the electric and optic ethers can we observe and measure so as to accurately compare them?

The first property we shall consider is the velocity with which waves travel in each case.

I mean we will compare the velocity with which light waves and waves of electric induction move in air and empty space.

In both cases a disturbance is propagated through the ether.

If a candle sends light to the eye, the disturbance—the wave, that is—travels over the space between.

Again, if an electric current by induction affects a magnet at a distance, the strain, or wave, or whatever it is, travels over the space between. With what velocities do the disturbances travel in each case? If these velocities can be measured, and if they can be shown to be the same, it will be a very strong argument for considering that the electric and optic ethers are identical, for the velocity with which a wave is propagated in a medium is a measure of its density and its elasticity.

The next property will be the velocities in other media. Both light and electro-magnetic induction are propagated with a different velocity in glass and other transparent solids and liquids to that which they have in air. If these velocities in glass, &c., still agree with each other, we shall have a still stronger reason for supposing that the ethers are not two, but one.

Before we go any further I should just like to remind you about what these velocities are which we are talking of measuring. That of light is, you know, about 185,000 miles per second, or it takes about eight minutes to pass through the 92 million miles between us and the sun.

The velocity of light has been measured directly in many ways. I can only indicate one of them here.

We see moving bodies, such as planets, &c., at any instant not in the position which they are at that instant, but in the position in which they were when the light left them. Thus, if a planet or star crossed the direct line through a telescope exactly at noon, it would not be seen in the telescope till some time after noon. The length of this time would depend on the distance which the light had to travel.

Now, the earth goes round a circle 184 million miles across, and, therefore, the light from some stars has to travel 184 million miles further at one part of the year than at six months later. If the instant at which one of these stars is seen to cross a fixed telescope is noted, and the same observation is repeated six months later, there will be found to be a difference of about sixteen minutes, which difference is due to the fact that at one time the distance from the star to the earth is longer by some 184 million miles than at the other. From exact measurements of this time the velocity of light has been determined.

Many other methods of measurement have been used. In one of which the time required by light to travel fourteen yards was determined, and the result agreed very well with the one where the distance was the diameter of the earth's orbit.

The velocity of electro-magnetic induction in air and empty space has not yet been measured directly. Probably no attempt at a direct measurement will ever be made, for we have an indirect method of computing it which is susceptible of far greater accuracy than is ever likely to be obtained by a direct measurement.

A comparison of electrostatic and electro-magnetic actions is the basis of this measurement. I fear the process is too purely mathematical to enable me to attempt to explain it in detail, but I can indicate the principle of it. If the same thing, such as the resistance which a wire offers to the passage of electricity, be measured both electro-statically and electro-magnetically, the numbers obtained for the result will not be the same.

The difference is caused by one set of measurements being based on the consideration of electricity at rest, and the other on the consideration of electricity in motion. Mathematics tell us that the ratio of the results is a motion or a velocity, and that this velocity is the velocity of electro-magnetic induction; therefore, from such measurements this velocity can be calculated.

* Delivered at the Royal Institution 1879.

The results obtained by different observers are in the left hand upper column of this table:—

VELOCITIES.

Medium.	Velocity of Light. Authority.	Miles per second.	Velocity of Electro-magnetic Induction. Miles per second.	Authority.
Air and Vacuum	Fizeau ...	195,100	193,000	Weber
	Astronomical observations	193,300	178,900	Maxwell
	Foucault...	185,300	175,200	Thomson
	Cornu	187,100	183,100	M'Kichan
			185,300	Ayrton & Perry
	Mean	189,700	183,100	Mean
		186,000		
Double extra dense flint glass	Gordon ...	106,400	104,600	Gordon
Extra dense flint glass ...		110,900	106,400	
Light flint glass		123,100	107,300	
Hard crown glass		116,800	105,500	
Paraffin	Gladstone and Maxwell	130,800	131,700	
Plate glass	Text Books	121,000	103,000	
Sulphur		89,000	115,000	
Bisulphide of Carbon		115,000	139,000	

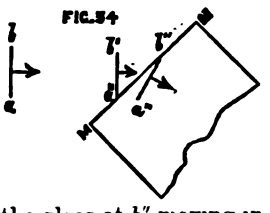
A comparison of the two upper columns of the table shows a very close agreement between the velocities of electro-magnetic induction and of light. You notice that the difference of the means of the two columns is less than the accidental differences between numbers in the same column. Thus we have seen that *in air and vacuum the velocities of light and electro-magnetic induction are sensibly equal.*

Now we will consider the case of glass and other transparent insulators.

In these light does not travel with the same velocity as in air.

How do we determine the velocity of light in glass. We do not determine it directly, but measure the difference of velocity in air and glass. Let *a*, *b* be the front of a wave of light travelling along in the direction of the arrow. Let it fall on a piece of glass M, M, placed diagonally to the direction of the ray or arrow. When the wave gets to the position *a'*, *b'* the lower part *a'* begins to enter the glass, the upper part *b'* is still in the air. But as light travels more slowly in glass than in air, by the time the top *b'* has got to the glass at *b''* moving in air, the lower part *a'*, moving in glass, has not travelled so far as the upper part, and has only got to *a''*. The lower part of the wave is retarded or dragged back behind the upper part and the wave, and, consequently, the direction of the ray is twisted round, so as to make an angle with its former direction.

FIG. 54



Suppose two people are pushing a two-wheeled cart along by turning the wheels. If one turns his wheel faster than the other does the direction in which the cart travels will be changed.

Now, if we measure the angle through which the cart turns we can calculate the difference in the speeds at which the two wheels are moving. Similarly, if we measure the angle through which our ray of light is turned, we can calculate the difference of the velocities with which the part in air and the part in glass were moving.

The lower left hand column of the table above shows the results of the calculations for the velocities of light.

The velocities of the electro-magnetic induction are calculated from the velocity in air.

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Theory shows that this calculation can be made when we know the specific inductive capacities.

The greater the specific inductive capacities the slower the induction travels.

The lower right-hand column of the table (page 219) shows the results of the calculations for the velocities of electric induction.*

You see that in certain dielectrics there is a very close agreement indeed, notably in paraffin and in some of the denser glasses; in others there is a very wide difference.

I am hoping shortly to make some further experiments both on sulphur and on bisulphide of carbon. I am not certain of the accuracy of my determination of the specific inductive capacity of bisulphide, as liquids present special difficulties; while, as to sulphur, it has so many different forms—yellow crystal, red powder, black plastic wax—that it is possible that the discrepancy may be partly accounted for by supposing that there was a difference in the physical state of the sulphur when the electrical and optical experiments were made.

At present, however, I think we may fairly say that in some dielectrics the velocity of electro-magnetic induction is nearly equal to the velocity of light. That there is almost always a small difference, and that sometimes there is a very large difference. That it is quite possible that the relation which we have spoken of between electric induction and light exists, namely, that they are disturbances of the same ether; but that there is some unknown disturbing cause affecting the electro-magnetic induction, and that in some dielectrics the disturbing cause is very small, but that it is in others large enough to cause a very large difference in the calculated velocities.

I am hoping some day to compare the electric inductions along and across the axis of the same crystal.

I hope that the disturbing cause, whatever it may be, may affect the inductions equally in both cases.

We know that the velocity of light in a crystal is different along and across the axis, and if then the ratio of the two light velocities were the same as the ratio of the two electro-magnetic velocities, we should have a confirmation of the theory independent of any knowledge of the nature of the disturbing cause.

What this disturbing cause may be we do not know. Perhaps some future investigation may explain its real nature.

I am now going to attempt to show you a few experiments to illustrate other connections between electricity and light experiments in which electricity acts on light and *vice versâ*. In fact, without too bold a hypothesis, we may call them experiments where, on the ether in certain bodies being disturbed by electricity, the disturbance is seen in their changed action on light, and where, when it is disturbed by light, their action on electricity is altered.

* The velocities in the lower half of the table are calculated from the refractive indices and specific inductive capacities given in the following table:—

Dielectric.	$\sqrt{K}$.	Nearest value of μ.	Ray for which μ is nearest.
Double extra dense flint glass	1·7783	1·7460	Band in extreme violet in magnesium spark spectrum.
Extra dense flint	1·7474	1·6757	
Light flint	1·7343	1·5113	
Hard crown	1·7629	1·5920	
Plate glass	1·8009	1·543	
Paraffin	1·4119	1·422	Rays of infinite wave length.
Sulphur	1·6060	2·115	
Bisulphide of carbon	1·3456	1·6114	

Here K is the specific inductive capacity, and $\sqrt{K}$ stands for the square root of K. μ is the refractive index.

Maxwell's theory gives that the velocity of electro-magnetic induction in any dielectric is to the velocity in air inversely as the square root of the specific inductive capacity. To determine the velocity of electro-magnetic induction in any dielectric, 186,000, the adopted mean velocity in air, is divided by the number under the heading $\sqrt{K}$ in this table.

We also know that the velocity of light in any medium is inversely as the refractive index μ. Hence the velocity of light in each dielectric is found by dividing 186,000 by the number under the heading μ.

The values of $\sqrt{K}$ are from the author's determinations of specific inductive capacity. μ was determined by the author for the first four glasses; for paraffin the value given is that calculated by Maxwell from Gladstone's experiments. For the other substances, where there is a wide difference, the values of μ are taken from the text books.

The first action which I will show you is the electro-magneti action discovered by Faraday.

Faraday found that if an electric current were made to circulate round and round a cylindrical ray of light, that, *in certain media*, the ray would be twisted, so that a line drawn along the outside of the ray would no longer be straight, but would be twisted spirally like the rifling of a gun.

But how are we to draw this line, and how see the twist of it?

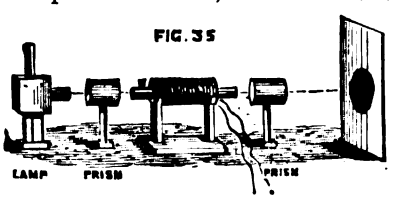
You know that in ordinary light the vibrations take place in every possible direction at right angles to the ray. Crystals of Iceland spar, cut and arranged in a particular way, called "Nicols' prisms," have, however, the power of compelling all the vibrations to take place in one particular plane, or of polarising the light, as it is called. In fact, when the light is plane polarised, we have a flat ray of light instead of a cylindrical one. Let us now pass light horizontally through a Nicols' prism, so as to polarise it, let us say, in a horizontal plane.

We shall now have extinguished all vibrations, except those in one plane, say the horizontal plane.

Let us now put a second prism, with its polarising plane vertical. It will have the power of extinguishing all horizontal vibrations, and it will, therefore, entirely extinguish all the light which has come from the first prism, as you see. But if the plane of the light is twisted by any means between the two prisms, it will no longer fall with its vibrations horizontal on the second prism, but will be partly allowed to pass, more and more of it being admitted as their plane is twisted more and more nearly vertical.

Here, between the prisms, is a tube with glass ends, filled with bisulphide of carbon, and here is a coil of wire of 1,028 turns, carrying an electric current round and round the tube. The light passes along the tube. The prisms are set to extinction. I turn on the electricity, and you see the re-appearance of the light on the screen shows that the plane of polarisation has been twisted. I have to turn the prism through about 14° to again extinguish it. The number of degrees which the prism has to be turned of course show the amount of twist that has been given to the light. On reversing the current the light reappears, and to extinguish it we have to turn the prism as far to the right of the zero as we previously turned it to the left.*

FIG. 35



Now, as many of you will know, a spiral current acts just like a magnetised bar would if placed in the spiral. In fact, if light is sent from pole to pole of a magnet, the same effect is produced on it as that which we have just seen. In 1877 a Paper of mine was published in the *Phil. Trans.*, containing measurements of the amount of twist which a unit magnetic force would give to a ray of light, and in the *Comptes Rendus* for 1878,† Mr. H. Becquerel pointed out that from these results we can calculate what would be the effect of the earth's magnetism on light in certain media.

If a canal one mile long were dug from N. to S. near Kew, and filled with bisulphide of carbon, a ray of green polarised light entering at one end would, by the action of the earth's magnetism, be twisted just 50°. (There are slight differences in the action on different coloured lights. The measurements were made on the green light of burning thallium.) If the canal had been full of distilled water the twist would have been about 7½°.

The explanation of this phenomenon is still exceedingly obscure. We as yet know so little about the molecular structure of bodies that there are very many gaps in the chain of reasoning that must either still be left empty or filled in with provisional hypotheses, that is, guesses.

What we do know on this subject may be briefly summed up as follows:—In the disturbance which we call light, whatever its true nature may be, we know that there is something like a rotation round an axis going on, which axis is the direction of the ray.

When magnetic forces act on a medium, Professor Maxwell has shown that there is always something like a rotation round an axis going on, which axis is the line of force. But here the resemblance stops. There is nothing in the magnetic phenomenon which corresponds to the wave length and wave propagation in the optical phenomena.

As to the nature of the rotation accompanying the magnetic forces, we know that it exists, and we know that it is not the rotation of any sensible portions of the medium as a whole.

Professor Clerk Maxwell suggests that it may be a rotation of "molecular vortices," that is, that every part of the magnetised

* *See* Faraday "Exp. Res," § 2,146, vol. iii.; and Verdet Œuvres, t. i., Notes et Mémoires.

† T. lxxxvi., p. 1,077.

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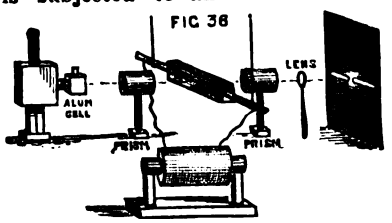
medium may be filled with little whirlpools exceedingly minute. These whirlpools may be motions of ultimate particles of matter, or may be motions of the ether in it, or possibly in this region of "very-smallness" the ether and the matter may be one. Now, as minute eddies in a stream whirl chips round but do not affect a large boat, so these whirlpools, while they cannot affect the sensible motions of bodies, may be able to influence greatly the minute vibrations which are the propagation of light.

The next experiment I have to tell you about is on the action of electrostatic induction upon light. You know that if light is sent through a crystal it is acted on in a way different to the action which occurs when it passes through a homogeneous medium. In particular, if light is plane polarised before it enters the crystal—that is, if its vibrations are all in one plane—then, after it emerges from the crystal, some of the vibrations will be circular, and in no position of the second Nicol can the light be extinguished.

In November, 1875, Dr. Kerr announced* that, when glass is subjected to an intense electrostatic strain, it acquires the same action on light as a crystal has. In fact, that the electric strain so rearranges the molecules of the glass that they act on light as if they were the naturally-arranged molecules of a crystal. Here is the method he used (Fig. 36), but the effect, though quite decided, is so minute, and the conditions of success are so delicate, that I have not much hope of showing the actual experiment to you.

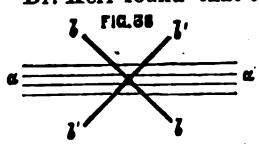
FIG 36



Here is a piece of thick plate glass, about eight inches long and two wide, having two holes drilled in it from the ends, so that they come within about 3-16th of an inch of each other (Fig. 37). Into these holes wires are cemented. These wires are connected to the secondary poles of the large induction coil, which we used last lecture (*see* Fig. 23), only now it is used with its full power, with ten quart-sized Grove cells and its own vibrating break. When the coil is worked, the tension across the 3-16th inch of glass is, of course, equal to the tension across the air between the discharging poles where the sparks are passing. By commencing with the poles close together, and then gradually drawing them apart, the tension across the glass can be increased as we please. The Nicols' prisms and a lens for focussing are arranged, as shown in Fig. 36. The alum cell is attached to the electric lamp to intercept the heat rays. Now, we turn the Nicols, so as to darken the screen, start the coil, and gradually draw the discharging poles apart. When we get to a tension equal to about 7 inches of air you see the patch of white light appearing on the screen. (This was clearly seen by a large audience.)†

FIG. 37

Dr. Kerr found that the maximum effect was produced when the prisms were so set that the line of electric strain was at 45° to the direction of optical vibration. (Fig. 38.) As the prisms are turned away from that position, the effect gets less and less, till, when the direction of vibration is either along or perpendicular to the line of strain, there is no effect at all.

FIG. 38

a a line of electric strain. *b b*, *b b* direction of optical vibration. Ray of light perpendicular to plane of paper.

We observe that in this experiment there is no rotation of plane polarised light as in the last, for no rotation of the Nicols will extinguish the light. It is found that the light, after emerging from the strained glass, is no longer plane-polarised, but that its vibrations are circular.

I have still one more experiment to show you.

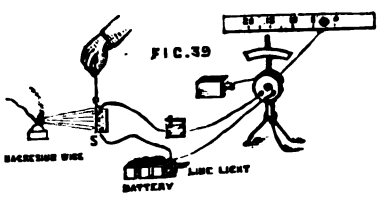
Here is a metal called selenium. It conducts electricity, but very badly—that is, it offers a great but not an infinite resistance to the straining force.

But it has this extraordinary property. It conducts much better in the light than in the dark. The light vibrations actually seem to shake its molecules, and help them to yield to the electric strain.

I will try to show you this experimentally.

Here you see the arrangement (Fig. 39). Here is a delicate reflecting *galvanometer* of high resistance. On pressing down the contact key the current from a ten-cell Leclanché battery flows through the galvanometer and through a piece of selenium enclosed in a light tight box, and you see the deflection of the needle moves the spot of light about 10 divisions of the scale. Now, we light this piece of magnesium wire, and draw up the sliding front of the box. The deflection is at once doubled, showing that in the light this selenium conducts about twice as well as in the dark.

FIG.39



Prof. W. G. Adams has made many experiments on this subject, and he found that light could actually *produce* a current of electricity, and not merely aid its passage.

Here is a box* containing a piece of selenium whose ends are connected to the galvanometer. I open the box and admit the light of the electric lamp, and here, you see, is a deflection of the galvanometer.

The electricity of a battery has been converted into light in the lamp, and here you see that this very same light is again converted into electricity.

Here, then, we have considered some few phenomena which we can explain, and a great many which we cannot. These experimental facts stand as yet alone and disjointed. Many lines of reasoning and research open out a little way, and then are lost in the darkness, or, rather, let us say in the brightness through which, as yet, human sight cannot pierce.

No doubt the day will come when all these difficult ways will be clear and trodden paths, when all these disjointed facts will be seen to be parts of one true, harmonious, and perfect whole.

* *Phil. Mag.*

† In rehearsing this experiment the day before, Mr. Cottrell, Mr. Valter (the second assistant), and myself only being present, the strain was accidentally allowed to become too great, and the glass was perforated. Immediately before perforation some extraordinary effects were seen on the screen. First appeared a patch of orange-brown light about six or seven inches diameter. This at once resolved itself into a series of four or five irregular concentric rings dark and orange brown, the outer one being, perhaps, 14 inches diameter. In about two seconds more these vanished and were succeeded by a huge black cross about 3 feet across, seen on a faintly luminous ground. The arms of the cross were along the planes of polarisation, and, therefore (the experiment being arranged according to Dr. Kerr's directions) were at 45° to the line of stress. The glass then gave way, and all the phenomena disappeared except the extreme ends of the cross, and the discharge through the hole, where the glass had been perforated, was alone seen. I have since made numerous attempts to repeat this effect, but have not succeeded in doing so, though I have perforated many valuable glasses. In this particular case the glass happened to break slowly. In all the repetitions of the experiment the glass has broken suddenly, and there has been no time for the new effects to occur.

THE EARLIEST CUP INSULATOR.

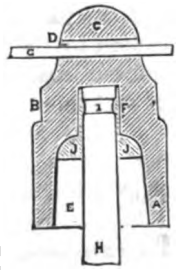
TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a contribution to the history of insulators I send you herewith a tracing, showing the insulator patented by Brett and Little in 1847. This insulator was used on the line from Maryport to Carlisle, where I saw many of them in 1852. This appears to be the earliest example of cup insulator with support below the insulator and wire on the top. The patent was dated Feb. 11, 1847, yet it was not until 1856 that the cup insulators supported from below were introduced as a novelty on the principal lines of the Electric Telegraph Company, and in the nine years intervening insulators far inferior to Brett and Little's were employed.

The following note from Mr. Little I found with the tracing when looking over some old papers. F. C. WEBB.

"Steamship Office, 150, Leadenhall-street, E.C.,
"London, April 8th, 1867.

"SIR: As promised, I herewith send you the exact size and form of the insulator invented by me in 1846, and now used with trifling modification throughout the United States of America and all parts of the world where overland lines are at work.



"A, the insulator, made of glass, earthenware, or other suitable material, secured to the arm H by means of the cement J J, which is run in so as to fill up the spaces I F. C, top of insulator, with its groove D, showing the line wire G G secured in the same. B, shoulder for supporting the winding or stretching apparatus.

"Claim—Insulators, bell-shaped in the interior, so as to prevent the rain establishing a circuit for the electricity from the wire to the support of the insulator.—Yours, &c., "GEO. LITTLE.

"F. C. Webb, Esq."

* This last experiment was omitted for want of time.

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THE ELECTRICIAN.

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NOTICE TO EDITORS.

Nous serons heureux de faire l'échange avec Messieurs les Rédacteurs des Journaux scientifiques qui recevront les premiers numéros de L'ELECTRICIAN.

Es wird uns ein Vergnügen sein mit den löblichen Redactionen der deutschen und anderen continentalen Journäle und Zeitschriften, denen die ersten Nos. des ELECTRICIAN *zu Händen kommen möchten auszutauschen.*

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THE ELECTRIC LIGHT IN AMERICA.

We have on more than one occasion stated that the panic in gas shares a few months ago was principally caused by the ignorance of the Press. The correspondents of our daily contemporaries vied with each other in making statements which no sane electrician would countenance for a moment. *The Times*, amongst others, was one of the offenders, and it is pleasant to find it giving space for an able article which will do much to allay the fears of timid gas shareholders. We may, however, point out that every case has its extremes, and generally, in the long run, attention is drawn from the extremes to some point between, which gives the reality of the case. It must be so in the case of the electric light. Numerous inventions, the outcome of the work of far abler men than any whose names have been of late prominent in the popular mind, have to be tried and condemned before the electric light can be consigned to the region of forgotten ideas. These men are in no haste to attract attention, frequently in no haste to visit the patent office. They are perfectly familiar with the work that has been done in England, on the Continent, and in America. They know the principles and laws of electrical science, and hence know what to hope for as the result of their labours. They do not say that an electric light cannot be diminished in dimness to compete with a fourteen-candle gas lamp, but what they do say is that it is improbable and would be uneconomical. The real worker does not arrogate to himself infallibility, but his present knowledge tells him that a light of fifteen thousand-candle power is more economical than one of fifteen-candle power. It is from an imperfect acquaintance with data well known to many of us, that some of our friends across the Atlantic have failed to realise their expectations. We do not believe that their labour has been lost; it has added to our unpublished, and, perhaps, unwritten stock of experimental details.

Before referring to the statements from America we will again state our opinion as regards the electric light. There is no present need for gas shareholders to be alarmed. The electric light cannot economically, as now maintained, compete with the street lamps giving the ordinary light, nor can it compete with gas in small rooms in ordinary houses. The future of the electric light, however, is a grand one. It can immediately replace gas in large spaces, and where a good light is of importance. We have wondered, again and again, why it has not been introduced into our theatres by enterprising managers, but confess we can find but one answer to the question. The managers owe too much to the fair sex to admit them to the searching glare of the electric lamp. Powder, paint, and tinsel would be too conspicuous, and, instead of aiding beauty, would cause the artificial glosses to be distressingly evident.

In railway stations, among shipping, at wide and well-used crossings in our streets, in factories where exactness is required, where much depends upon the use of true colour, these are places where an immediate, advantageous, and economic use can be made of the electric light.

The following extract from *The Times* refers to the Edison light:—"It is now known that Mr. Edison has failed in his experiments. The most that he has ever yet accomplished has been to maintain 400 coiled iron wires in a state of partial incandescence with a 16 horse-power steam engine. The object of this experiment was to ascertain the number of coils which could be brought to a red heat in any given circuit. It is upon this experiment that Mr. Edison based his claim that he could maintain 20,000 lights burning from one electrical station with a 600 horse-power engine. The conclusion was a fallacious one, as Mr. Edison now knows. Platinum must be heated to 2,700° before it attains the intensity of incandescence which is required for illumination, and when the metal is as hot as that it is just on the verge of melting. To prevent the lamp from melting, this inventor has used a regulator, consisting of a bar of metal through which the current flowed, which, when the current became too strong, expanded and switched off a part of the current and thus saved the lamp. In practice this regulator has failed to perform the service required of it. When the current becomes strong, the platinum burner melts in the twinkling of an eye, and the mischief is done before the regulator can act. The inventor believed that he could overcome this practical difficulty, but he has not succeeded. His lamps have continually melted and he has been unable

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to keep them from doing so, and the result is that there is great discouragement at Menlo Park. There has been another difficulty. Fourteen out of Edison's sixteen applications for a patent at the Washington Patent Office have been rejected. This impulsive man took up the electric light last fall as an entirely new subject of experiment, and allowed himself to believe that he saw a way to make the light useful which others had never thought of; but when he reached the Patent Office he discovered that very nearly every idea which he had embodied in his applications had either been covered by the patents of other inventors, or was not patentable at all. This information is obtained from the Patent Office, and is one explanation of the discouragement which reigns at Menlo Park. There is no doubt that the Edison light would be a delightful resource for the illumination of dwellings if it could be depended upon. It floods a room as though with golden sunlight—pure, brilliant, and mellow. But the inventor has never yet been able to regulate his current so as to keep his lamps burning for any length of time, and he has never ventured on a single public exhibition of it. The public have never seen so much as one of his lights yet. A favoured few who have been admitted to his laboratory at Menlo Park have beheld it—a single lamp, enclosed in a glass globe, beautiful as the light of the morning star. But he has refused to let any one inspect it closely, and has never allowed the exhibition of it privately to last long. He has never been able to depend upon its durability. His apparatus is as far from perfection as it ever was, and, in fact, well-informed electricians in New York do not now believe that Mr. Edison is even on the right line of experiment."

The correspondent who writes this goes on to criticise adversely the Sawyer light. What he states, however, is exactly what electricians have long ago stated. Neither Mr. Edison nor Mr. Sawyer experimented in a new direction. Perhaps they were not acquainted with the long series of experiments made in Europe, and always made with one result—failure. Mr. Sawyer would use incandescent carbon in an hermetically sealed globe, containing nitrogen. We have long ago pointed out that he need not trouble himself to fill his globe with nitrogen. If he will but hermetically seal it and allow the light to burn for a short time, the tube will lose all its oxygen and contain no gas that will oxidise his carbon. As we say, all previous attempts in this direction have ended in failure, and we have no reason to think that Mr. Sawyer is a better chemist, or a better mechanist that the experimentalists in this direction who have preceded him and failed. Even, however, if he could obtain his much coveted globe, and obtain freedom from breaking, we can say his light will be economically a failure, as must all lights by incandescence.

Whenever we enter into this subject it grows upon us, and we fear to weary our readers. Before the electric light can become general the public must be educated to require a better and a purer light, and be willing to pay a little more for it. Electricians can and will supply it much cheaper than it is to be obtained at present, but there is a margin which science as yet does not tell us how to pass. The education is rapidly going on, and electricians need fear no dimunition of the field for the use of the electric light.

ANSWER TO CORRESPONDENT.

E. Hospitalier.—The meg-erg is 100 metre-gram-second units of work, and, since those units $= \frac{1}{9{\cdot}811}$ gram-metres, the meg-erg $= 10{\cdot}1926$ gram-metres.

TELEGRAPH COMMUNICATION WITH THE CAPE.

We are glad to find that the Government has at length decided to conclude arrangements with the Eastern Telegraph Company, to connect the cable system of that company with South Africa. It seems that this decision was made at the Cabinet Council on Wednesday, 26th March. Two thousand miles or so of cable are already manufactured, and will be despatched immediately, so that in the course of a few weeks we may hear that Natal is practically within speaking distance of England. It is stated that the first ship will sail directly to Natal, and commence laying the cable towards Aden; other ships will be ready with sections of the line and commence laying from Aden, so that working in both directions the whole work will be completed in the least possible time. The cable is to be worked under the general administration of the Eastern Telegraph Company. We have long held that this is the only practicable route, and it must be patent to all who have carefully thought over the subject, that the overland route scheme, so constantly put forward, is one of the most chimerical projects ever conceived in the mind of man. It is probable that the Eastern Telegraph Company will now endeavour not only to connect the South African Colonies telegraphically with England, but also to lay a branch cable to the Mauritius.

TELEGRAPHY; WHAT IT IS, WHAT IT HAS DONE, AND IS DOING.

BY SIR J. ANDERSON.

[The following lecture was delivered at the Working Men's College on March 6. Mr. J. Pender, M.P., presided, and introduced the lecturer with a short but eminently practical speech. The lecture, delivered, as it was, to men presumably ignorant of electrical science, is, so far as the scientific portion is concerned, quite elementary.—Ed. *E.*]

I propose to explain, in the simplest manner within my power, and without the use of any technical or scientific terms, first, what constitutes the force we call electricity, and how we apply it for the purpose of communicating with each other at great distances, which we call telegraphy.

Then I shall endeavour to show you the effect this comparatively new method of communicating by electricity has had upon the commerce, the capital, and labour of the world.

I will assume that comparatively few in this room or of the general public know or have time to know with any accuracy by what means the electricity is produced which sends signals thousands of miles along a wire, and why there should be, or if there is, a difference in signalling along a wire through the air and along a wire under the ground or under the ocean.

It need not be termed ignorance not to know or thoroughly understand these points. Nearly all of use are so occupied with our daily avocations in the struggle of life that we must pick up much information outside our own business as well as we can, and as opportunity offers, or else do without it.

The number of very studious people in any community are very few—relatively; and the number who must work every day as long as they are able are and will always be the greatest number.

I will suppose, then, that you are willing to hear this subject treated, and so simply illustrated, that with a little attention you may never afterwards be ignorant of the general principles.

Electricity.

I shall now explain and illustrate how electricity is produced.

Whenever two dissimilar metals are placed near each other, with a porous or fluid substance between them which will act chemically on *one* of the metals *only*, you have what is termed a galvanic battery, so called from the circumstance that about the end of the last century "Professor Galvani discovered that convulsions were produced in the limbs of a frog by establishing communications between the nerves and muscles by means of metals." And "Professor Volta, of Italy, showed that electricity might be developed by arranging discs of silver-moistened cardboard and zinc placed alternately on each other."

From these simple foundations have sprung all other forms of galvanic and voltaic batteries, and the force which is generated by these batteries is termed electricity.

This electric force is produced by the waste of one of the metals, and neither this nor any other force can be produced without the

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consumption or waste of something or another, otherwise we should at once have discovered perpetual motion, and there would be no necessity for mainsprings for watches nor of coals for steam engines, and so on.

What electricity is we do not know; it is only a name, just as we speak of life or heat or gravitation. We know nothing more about one or the other than that they exist. Under certain conditions they are forces which we use to the best advantage for such objects as may seem to us desirable, and they may all of them be electricity for anything we know—they probably are electricity.

BATTERY.

I shall now illustrate a battery. We have in this glass vessel two plates of metal, one of copper the other zinc. They are placed in a fluid. Fresh water alone, still more salt water, or sulphate of copper (common blue stone), or vinegar or sulphuric acid, would set up an electric current at the cost of eating away or consuming the zinc. The strength of the electric force which is liberated will depend upon the strength of the solution and the amount of zinc consumed, so that in order to get a large amount of force you must increase the size or multiply these cells by connecting one with the other to any extent required, as illustrated by these cells, which you see connected one with the other.

When sufficient electricity is required to light the street lamps you must use a steam engine to drive a machine to generate an electric current and keep up an active consumption of carbon to generate the light. So that it is still indispensable to use coal or gas to move the engine which produces electricity by consuming something else. For this reason it can never be an inexpensive luxury.

Whenever these plates are brought into contact outside the fluid, a current flows from the copper to the zinc, and the current which is given off by the copper is termed positive electricity and that from the zinc negative electricity.

I shall illustrate this by the well-known and simple experiment of winding round a rod of iron, which might be a common kitchen poker, a length of wire covered with cotton, and so covered to prevent the electric current rushing off at any point where the coil might touch the poker, or touch any of its own points.

If we now apply the current to this coil of wire the poker at once becomes an electro-magnet, and has the power of attracting these nails for example; it also assumes at once all the properties of the magnet, and has two poles, one end of which you will see will attract another magnetic needle, and the other end as you see repels it.

This is a well-known law of the magnetic needle, poles of the same name repel each other, and poles of opposite name attract each other, so that actually the end of the needle of the magnetic compass, which points north, is in reality the south pole of the needle.

It is this property of the magnet which enables us in telegraphing to send signals to the right and left at the will of the operator, and produce signals described in diagram No. 1 (Recorder), or by the mirror system, which can be described by supposing this mirror, with a magnetic needle across its back, to be suspended in this coil of wire. One current from the copper would make it incline to the right, and the zinc to the left. Those signals to the right you would call dots. Those to the left we call dashes, and thus we have the power of moving at will a small magnet, weighing less than a grain, thousands of miles away by a feeble current sent through a cable.

The ordinary Morse signals (of which diagrams were shown) are produced by the operator touching a key, which connects the battery with the line, and by making short or long contacts, thus producing those dots and dashes, such as are illustrated in the diagram shown, which you see represent the letters of the alphabet.

Some of our experts are so proficient at this work, that they can send forty words per minute, equal to 600 signals.

By a mechanical method with the signals prepared beforehand, by punching upon strips of paper, as here illustrated, 400 words per minute have been sent in this country; and in America, where the atmosphere is dryer, 1,000 words per minute have been sent.

The only value of this is for telegraphing long Parliamentary speeches, or columns of news, which can be prepared during the busy hours of the day or evening, and sent off when the wires are not occupied with other traffic. For this reason this class of message is transmitted very cheaply.

I shall now describe the difference between an aerial line and an undergroud line and a submarine cable.

Every substance in the world will conduct heat or electricity, but some things are such bad conductors that they are called non-conductors. And amongst the best conductors is, first, silver wire, then copper, and we can nowadays manufacture a class of iron wire specially suitable for conducting electricity. Next, water and the earth, on account of their great mass, are good conductors.

The very bad conductors which we know as the most valuable non-conductors are glass, highly glazed porcelain, india rubber, and gutta percha, and best of all, the air itself, especially when dry.

You will now see the reason for the wires which you see over your heads everywhere you go being supported clear of the ground, and fastened to porcelain cups which are called insulators. If these cups were to break or become porous, some of the current would escape down the pole, and if the wire rested on the wooden pole, or if a branch of a tree fell across the wire, the working of the line would be very defective, and if the day were wet it would be useless until the difficulty was removed.

It is a popular notion even yet to apprehend that lightning rods attract lightning, which you know is electricity. This, however, is altogether wrong. The lightning rod is a better conductor than anything else usually in the neighbourhood. So that if the lightning is there, it will, like the current from the battery, rush along the channel prepared for it, and go into the earth rather than shatter its force against such bad conductors as bricks and mortar. Water follows the same law, and will flow into a channel ready for it before it will seek to force its way in any other direction.

A land line, then, is the most effective, simplest, and cheapest conductor in the world for all telegraphic purposes, as you cannot injure the air by any amount of electric current, nor yet damage the wire by any amount which science requires. You can apply such an amount of electrical force as to give you great speed, or ring bells, or fire cannons many miles distant from your battery.

But there are objections to the too great multiplication of wires overhead, especially in great cities, and the system is growing of putting wires under the ground. Already in the City of London there are 4,500 miles of wire underground, and to adapt a wire for underground it must be covered with some non-conductor, such as gutta percha, to keep it from touching the earth.

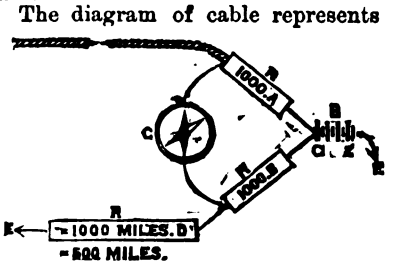
The same applies to submarine cables; they must be so covered to keep the wire from touching the water, or the cable would be useless.

Now, when a wire is encased with any substance, you have altogether different conditions from that of a wire in the air.

You have, in fact, a tube or pipe which the electric current must go through, all the time trying to escape as it goes along, so that if there should arise the most minute puncture at any spot along the whole line this would gradually become larger and larger, until the whole current sent in would flow through it and none would reach the further end to convey the signal.

We should then have a fault in the cable, and I will now illustrate the principles upon which the position of the fault is determined.

The diagram of cable represents the arrangement of the apparatus. In these boxes A B are resistance coils, formed of small wire insulated by a covering of silk thread and paraffin wax, and wound round a bobbin. Each of those bobbins are made so as to give a resistance equal to so many miles of cable.



The box D contains various coils, ranging from one mile up to 1,000 miles of resistance, and can be varied at pleasure.

These boxes A and B are connected together so as to correspond to the beam of a pair of scales.

The box D corresponds to the weight on one side of the scales and is connected to the box B one end of the beam of the scales, and the cable which is connected with box A corresponds to the thing to be weighed.

When the battery is connected, as shown in the diagram, with the copper plate to the junction between the boxes A and B, and the zinc plate to earth, the electricity divides equally between the boxes A and B, then the current flows through the cable to the earth at the other end of the cable on the one side and through the resistance box D to earth on the other side. Thus the current being equally divided the galvanometer needle is balanced and remains fixed at zero. Now, if a fault or break occurs in the cable, say at 500 miles, the needle, which was steady at zero when all was well and both the weight and the thing weighed were equal, as it no longer has the same resistance or weight at the cable side, it, the needle, will fly to the right as shown by the red needle. You would then remove from the box D various coils until you had the needle back again at the point

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at which it stood when perfect, and if the resistance coils which remained equalled 500 miles you would say the fault in the cable was 500 miles distant.

There are, of course, other tests, elaborate calculations, and much experience required to determine the position of a fault or break with any accuracy, but what I have described is the main principle, and sufficient to fix in the mind that the finding of a fault or break either in land or submarine lines is a *question of balance*.

The diagram before you will illustrate at a glance the process by which a cable is lifted from the bottom of theocean. You take the ship over the spot where the cable lies injured. Then you anchor buoys for the purpose of showing you the direction in which the ship is drifting, as you have no hedges, or trees, or landmarks by which you can ascertain the drift of your ship. Then you lower your grapnel, hook the cable, and lift it.

Should the cable be lifted as here described, the distance from the two points where it touches the bottom, supposing the depth to be two miles, would be nine miles. This will be sufficient to illustrate that the whole operation is costly, difficult, and at such great depths not always successful, unless the cable is nearly new and the weather favourable.

We shall now assume the cable to be successfully repaired, and in complete working order.

It must then be worked with a much smaller battery power than can be used with impunity upon land lines; for one reason amongst others you cannot force a rapid succession of strong current through this small tube, which a cable resembles.

We might illustrate the difference of a land line and cable by imagining a short water pipe with a water wheel at the one end, the water will fill and flow through the short pipe instantly and turn the wheel, but with a pipe of great length the water is longer in filling it, and takes longer to get to the end to turn the wheel. The short pipe represents the land line, the long pipe the submarine cable.

This retardation to the flowing of a current of electricity through a cable, or the flowing of a stream of water through a pipe increases as the square of the length of the pipe or distance, that is to say, if you double the length of your cable the retardation is increased four times, and if you treble the length of your cable the retardation is increased nine times. I am indebted to Dr. Muirhead for this familiar illustration. You can readily comprehend that a pipe two miles long will take twice the amount of water and twice the time to fill which would be required in a pipe one mile long, and when you continue this squaring of quantity and resistance to thousands of miles the element becomes of the greatest importance, and is in fact a barrier to the rapid transmission of signalling through long cables, which science has only overcome to a very limited extent. In practice, according to Willoughby Smith, one of the most experienced practical electricians of the day, no more of the electric current arrives at the distant end of a long submarine cable of, say, 2,000 miles, to make the signal than is produced by an active seamstress plying her needle.

This law of resistance increasing as the square seems to pervade every force in nature, from the motion of the planet to the speed of a vessel through the water, the resistance increases as the square of the velocity; and in the case of the electric current the resistance increases as the square of the distance. An exact mathematical principle pervades every force in the universe. There is nothing accidental in nature's laws.

High rates of speed can be got through short lengths of cable. A few miles, say 50, you may get 200 words per minute, and perhaps 50 words per minute through 100 miles, but when you come to long cables of 2,000 miles you must enlarge the size of your copper wire and insulator to a great extent to get even 20 words per minute.

This would be relatively the same whether you had to conduct water or electricity. If you want the same volume through in a given time you must increase the size of the channel. Resistance to a rapid flow of anything through a contracted channel must decrease the speed.

As already explained, there are two kinds of electricity, positive and negative, and when speed of signalling is of great consideration, as it generally is, you send in these currents alternately, and at a speed as great as they can be made to arrive at the other end and produce signals; and at this point the two currents, positive and negative, which I have already illustrated by the electro-magnet, become of practical value in increasing the speed.

I have now shown as far as I consider necessary for a simple comprehension of the leading principles:

1st. How electricity is produced.

2nd. How it is applied to telegraphy.

3rd. The very great difference between an aerial line and a submarine cable or insulated wire.

4th. That the determination of the position of a fault in any line is a question of balance of resistances; and I now come to consider the effect of this force upon commerce, capital, and labour.

(TO BE CONTINUED.)

EDISON'S NEW TELEPHONE RECEIVER.

The following illustrations will enable our readers to obtain a fair idea of this intrument. As we stated in our last issue these diagrams illustrate an experimental instrument, and not one that is definitely adopted for ordinary use. Fig. 1 shows the

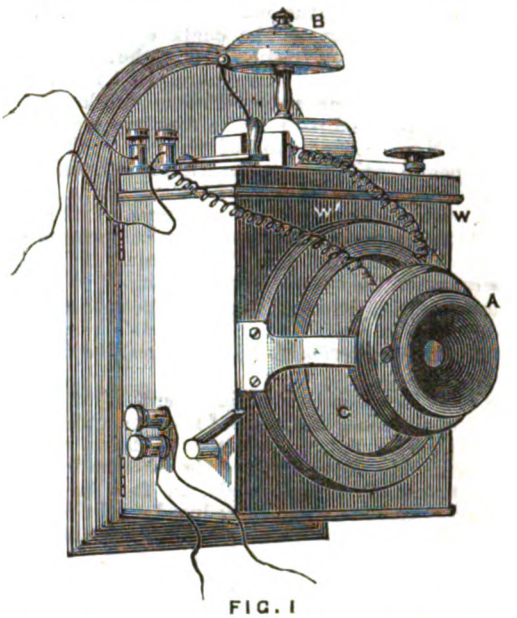

FIG. 1

transmitting telephone A, the call bell B, and the receiving diaphragm C. The connecting wires W W' show the connections between the transmitter and the binding screws to the battery. This part of the apparatus is, however, well known. It is the receiving apparatus shown in Fig. 2 that is new. F F is a cast

FIG. 2

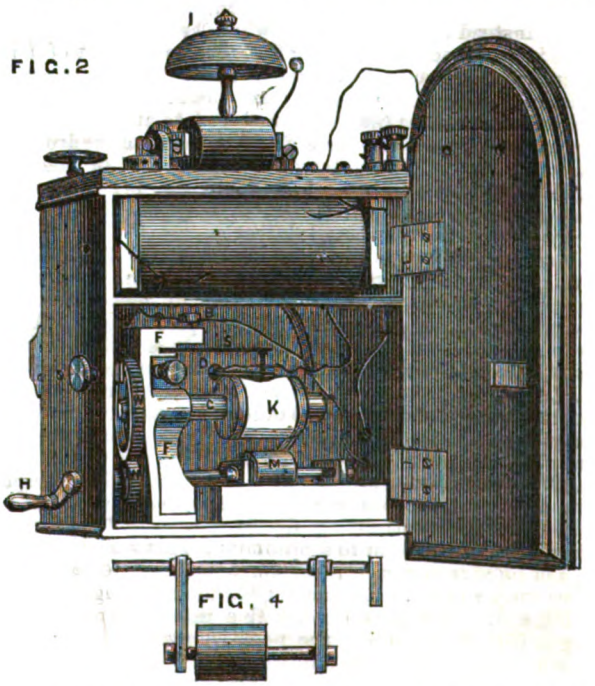

FIG. 4

iron standard, into which one end of the spring S is rigidly fixed. The pressure which this spring exerts can be regulated by the screw B. The axle C is supported by the boss in F F, and is connected to the handle H by the train of wheels W W. This handle can be rotated by hand, or, preferably, by an automatic arrangement; in these experimental instruments however the

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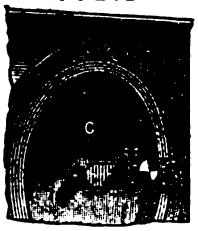
former is used. Upon the axle C is placed a chemically prepared cylinder of chalk K. This cylinder is simply a composition of chalk and potassium hydrate with a small quantity of acetate of mercury, moulded round a flanged reel of brass, lined with platinum on the parts in contact with the mixture. Upon and at right angles to this cylinder is a metallic strip, fastened to the diaphragm at D. The pressure of this metallic strip is regulated by the adjustable spring S. These parts really constitute the instrument. The diaphragm shown more clearly in Fig. 3 consists of a plate of mica 4in. in diameter. Fig. 4 shows a roller, seen also at M in Fig. 2, used to moisten occasionally the chalk cylinder. This operation will probably, in the working instrument, be performed by capillary action.

FIG. 3



The action of the apparatus may now be described. Between the metallic strip resting on the chalk cylinder and the chalk there is a certain amount of friction, and if the cylinder be caused to rotate, say away from the diaphragm, this friction tends to draw the diaphragm towards the cylinder; similarly on causing rotation in the opposite direction the diaphragm is pushed from the cylinder. Now, the amount of pull or push given to the mica plate depends entirely upon the friction between the cylinder and metal. Friction, as is well-known, depends (1) upon the materials in contact (2) upon the roughness of the surfaces in contact, and (3) is proportional to the mutual pressures between the surfaces. The extent of surface in contact is immaterial, as is the velocity when the system is in motion.

THE PROBLEM MR. EDISON PROCEEDED TO SOLVE IS THIS: *Given two surfaces in contact, it is required to vary by means of electricity, and in proportion to sound waves, the friction exerted between these surfaces.*

The directions in which to work in order to obtain the solution are indicated in the foregoing laws of friction. The materials in contact could be changed, the surface roughness altered, or the pressure varied. Mr. Edison solved the problem by varying the surface roughness of the materials, in fact he followed the example of every engineer, and introduced a lubricant. Whether this lubricant is sufficient to be called a change of materials in contact is a question which theoretically is worth discussing. At present we prefer to accept the simpler solution. We may digress for an instant, and say to our readers that in experimental work we should advise some such plan to be followed as is here indicated. *First*, decide what is wanted; *secondly*, state the problem as concisely and clearly as you can; *thirdly*, tabulate the first principles with which you can work. Discovery then becomes a mere matter of routine.

Supposing potassic hydrate alone to be used, the plan pursued is, by means of chemical decomposition, to provide a *hydrogen lubricant* instead of a metal plate (when the latter is the cathode) to come into contact with the chalk. The co-efficient of friction between hydrogen and chalk is not the same as the co-efficient of friction between the metal and chalk. We suppose the hydrogen to make less rough the metal plate and not to entirely cover the metal so as to have friction between hydrogen and chalk surfaces. If, as is stated above, acetate of mercury is used, then mercury will become the lubricant, or, if the acetate is in extremely small quantities, it may be that hydrogen-mercury alloy is the resulting lubricator.

So long as a change is thus provided, any modification of friction will modify the movement of the diaphragm. Let the handle H be turned, the mechanical operation will cause the rotation of the cylinder C, and the result will be a pull upon D. The motion of the diaphragm is almost immediately arrested, as its elasticity is opposed to the frictional movement and equilibrium results. Any change in the amount of friction destroys the equilibrium, and motion one way or the other takes place. Although the velocity of sound waves is large compared with ordinary velocities, it is small compared with molecular velocities and the velocity of light. Between any two sound waves there is a period of repose—infinitessimally short, it is true, but still repose. The sound waves impinging on the transmitting diaphragm exert there an effect varying from a maximum to a minimum. This variation causes a change of pressure upon the carbon telephone, thus varies the line current, and exercises a varying electro-chemical action at the receiving end. In a given time, with a maximum current, more hydrogen is generated upon the negative plate; in other words, there is a good supply of the lubricant, and, therefore, the friction is lessened. As the current varies, so does the supply of the lubricant, and, consequently, there is a variation in the friction between the surfaces. This variation of friction is shown by the motion of the diaphragm. The sound waves, then, in the first place, regulate the current, this regulates the lubrication of the surfaces, and this determines the action of the receiving diaphragm. The secret of the instrument is before our readers; if our interpretation of the action is incorrect, we should be glad to receive enlightenment.

ON "THE NEW THEORY OF TERRESTRIAL MAGNETISM."

BY ALEXANDER MUIRHEAD, D.SC.

In the issue of the *Engineering* for the 14th of March there appears a very amusing review of the "New Theory of Terrestrial Magnetism," communicated by Professors Ayrton and Perry to the Physical Society at the meeting on the 7th inst. The fun of the article arises from a total misconception on the part of the reviewer of the aim of the paper in question, for when he asks whether "they have subjected their magnetic speculations to severe, varied, and repeated examination," he shows how completely he has lost sight of the fact that their theory is not based upon any doubtful experiments but is a *logical mathematical* consequence of the experiments performed by Mr. Rowland in Professor Helmholtz's laboratory, and published by Professor Helmholtz in the *Philosophical Magazine* for September, 1876. These experiments (of which the reviewer makes absolutely no mention in his article) proved that a quantity of statical electricity in mechanical motion acted like a current in deflecting a magnetic needle.

Starting with this result, Professors Ayrton and Perry have deduced the following conclusion:—Since the points near the surface of the earth have different linear velocities from those in the interior (although all the points have the same angular velocity of rotation round the earth's axis), it follows that if the earth had an initial electrical charge, residing, of course in accordance with the well known electrical law, on its surface, the electrified particles would have velocities relative to the remainder; hence, as a direct consequence of the results of experiments published by Prof. Helmholtz, the interior of the earth would be a magnetic field; and this conclusion, contrary to the conception gained by the reviewer of the paper, is totally independent of the internal constitution of the earth, or of the existence of any other bodies in the universe. From exactly similar reasoning it follows, of course, that the space outside the earth would also be a magnetic field.

Next they have deduced mathematically (again be it remembered without any special assumption regarding the earth's interior) that if the earth had an angular velocity of rotation round its axis w, and a uniform electric density o, then there *must* be an electro-magnetic potential at any point inside the earth equal to $\frac{4\pi}{3} 2\sigma\omega r \cos.\ \theta$, and at any point outside the earth equal to $\frac{4\pi}{3} 2\sigma\omega \frac{1}{r^2} \cos.\ \theta$, where the unit of length is the earth's radius, r the distance from the earth's centre of the place in question, and θ its co-latitude.

Now, the value of the magnetic intensity at different points of the earth's surface coexisting with this electro-magnetic potential will depend on the interior constitution of the earth, so that to apply their conclusion they must necessarily make some assumption of the constitution; and, as an example, they have, taking the case of a spherical iron shell, been led by close mathematical analysis to the following result. If such an iron shell has an initial uniform charge of static electricity, and if it has an angular velocity of rotation round a diameter, then, independently of all other bodies in the universe, and independently of the coefficient of magnetisation of this iron, there will be, at any point on the surface of the sphere having a latitude λ, a magnetic force proportional to $\sqrt{1 + 3\sin.^2 \lambda}$.

Now, this result is identical with Biot's well-known formula for the distribution of magnetic intensity on the earth's surface. Hence, so far from agreeing with the reviewer that their theory of terrestrial magnetism is visionary, I cannot but feel that it has much weight.

Lastly, to get a rough approximation of what must be the difference of electric potentials between inter-planetary space and the earth, so that its own electric charge alone combined with its known rate of rotation round its axis shall produce the earth's magnetic moment, as determined by Gauss, they have taken as an example a solid spere of iron of the size of the earth, and rotating with the earth's velocity, and have proved that a difference of potentials of about a hundred million volts would be sufficient. Now, as they remark, there would be no difficulty in imagining such a difference of potentials, or a much higher one, to be maintained, seeing that the earth is surrounded by millions of miles of inter-planetary space, of which the insulation is probably far higher than that of the best Crooke's vacuum, and experience has shown that some thousands of cells cannot cause a discharge across even a thin film of such a vacuum.

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In the review there is given a confused description of some body, A, moving near some body, B; and this, I presume, is the reviewer's account of the ingenious explanation suggested (as introductory to his paper) by Professor Ayrton, and borne out as he described by some unpublished experiments of my own, of the cause why metallic screens do not shield a body from current induction as they are known to do from static induction. But this suggestion, which, be it right or wrong, does not at all affect the proposed theory of terrestrial magnetism, since the one does not in any way depend on the other, the reviewer has been so unfortunate as to call the foundation of the new theory, and so having raised a phantom of his own imagination has marshalled his forces to destroy it.

A QUESTION FOR STUDENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should feel much obliged if one of your contributors would inform me if there is anything new in the following experiment. If a piece of copper wire is bent into a narrow loop, say about the width of a finger, and the free ends connected with a galvanic battery, it will be found that one face of the loop is positive and the other negative, and on presenting the loop to a magnetised steel needle, the north and south ends of the needle will be attracted or repelled, according to which side of the loop is approached to it. If now you reverse the current in the wire by turning the battery round and attaching that end of the wire to the zinc which before was attached to the copper, the magnetism (if I may call it so) of the loop will be also reversed, and that face of the loop which before was positive will now be negative. For convenience I take a piece of stout copper wire about eight inches long, bend it into a narrow loop, pass the ends through a cork, and connect by fine wire to the battery. If instead of bending the wire into a loop the middle part is twisted into a helix, one end of the helix will be positive and the other negative, that end being positive which is nearest to the positive pole of the battery.

Can this be explained by the twist or strain theory of electricity? I fancy that if a bar is twisted, one side or the other would have a greater strain on it, according to whether it was a right or left handed twist, but I speak only as an amateur.—

Yours, &c., E. A. W.

15, Ladbroke-gardens, Notting-hill, W.,
March 17th, 1879.

THE DIRECT UNITED STATES CABLE COMPANY (LIMITED).

Proceedings at the Third Ordinary General Meeting of the Direct United States Cable Company (Limited), held at the Cannon-street Hotel on Friday, the 21st day of March, 1879, John Pender, Esq., M.P., in the chair.

The SECRETARY read the notice convening the meeting.

The report having been taken as read,

The CHAIRMAN said: Gentlemen, before asking you to approve of the report, I think it is right that I should make, as I have done on previous occasions, a few remarks on the report, and also as to the general position of the Company's affairs at the present moment. You have the report in your hands, and in it we have referred very fully to the working of the Company during the past half year. You will observe that it is a satisfactory account, and that the prosperity which dawned upon this Company when we rescued it from the unsatisfactory position in which it had so long remained, is continuing, and that our revenue is maintained. Our revenue for the half year under review, after deducting rent of land lines and payment to Anglo Company, amounted to £89,943 14s. 8d. The working expenses, interest on debentures of the old company, income tax, and all other charges absorb £21,748 9s. 11d., leaving a balance of profit of £68,195 4s. 9d. This balance being added to the sum brought from the preceding half year amounts to £71,128 8s. 4d., which has been dealt with as follows:—Two interim dividends of 5s. each per share, requiring together a sum of £30,355, have been paid; an amount of £32,500 has been added to the reserve fund; £3,000 has been written off the preliminary expenditure; and the balance of £5,273 8s. 4. has been carried forward. A comparison of these figures with those for the corresponding period of 1877 gives the following result:—The gross earnings, in spite of the general depression in trade, have increased by £5,700, being at the rate of nearly 7 per cent. This is an important fact, and must be very gratifying to the shareholders. The total expenses show a decrease of £3,300; equal to 13 per cent. This decrease, however, is principally due to the comparison being made with the December half of 1877, in which period we incurred expenditure for repairs. Deducting this item for repairs, in order to make the comparison a fair one, it will be found that our working expenditure has been slightly reduced in the half year ended December last. This reduction would have been very considerable, but for the new charge for duplex royalty—an item which did not appear in the accounts for 1877. This, gentlemen, is the bright side of the picture, and I should have been glad to have closed my remarks with a general expression of congratulation, but there is another view of the picture to which I must draw your attention. When I had the pleasure of addressing you on the 2nd of August last, I congratulated the shareholders upon the satisfactory position at which the Company had arrived after a great deal of trouble and contention with interested parties, and a very great deal of obstruction, which I may say continued until the other day when the arbitration was closed by the delivery of the award. The claim that one of the dissentient shareholders put forward was for a sum of £76,143. That is, he took his shares to be worth £76 each, the par value being £20. The actual amount awarded to him is £15,000, or £15 per share, which is practically £13,000, or £13 per share, allowing for interest from the time when the Company was reconstituted. Mr. Loeffler who was the leader of the party who insisted upon the arbitration—and Mr. Loeffler was one of the parties who took an active part in it—tried to prove that the share value was £76, but after the most careful judicial consideration of the whole case the result has been what I have told you, namely, just the same sum that Mr. Loeffler would have received if he had chosen to accept it, at the time the Company was put into liquidation. Now, gentlemen, to bring about this business cost a sum of something like £10,000. These costs will, of course, be taxed. It is a very large sum of money, and might just as well have been thrown into the sea. He had a perfect right, I believe, to go to arbitration, but so far as pecuniary considerations are concerned I believe he would have been a richer man if he had accepted the £13. Now, gentlemen, there is another subject which I think it worth while drawing your attention to. You have heard, I dare say, at least those who have been in the City must have heard, a great deal of talk about a new French company. Some parties went to France, and, assisted by a French combination, endeavoured to promote a new scheme. They have secured the assistance of two or three financial companies in Paris, and it has astonished me to find that companies such as those who are taking an interest in this scheme should have looked so little into the facts and figures, for if they had I am satisfied that they would never have taken up the scheme, which must prove so unsatisfactory to the French public, whom they are seeking to induce to take an interest in the undertaking. However, when your Directors became aware that this scheme was being talked of in Paris, we decided that it would be well to see the heads of the financial establishments who were promoting it. I went to Paris, accompanied by other gentlemen interested in Atlantic submarine telegraphy, and we at once interviewed the leading men connected with the financial companies I have spoken of. We put before them our figures, we showed them that they were bringing before the public a scheme with a capital of upwards of £2,000,000 for two cables, or, say, about double the capital of the Direct Company. I told them plainly that our Company had many advantages in its greater security from its connection with the Anglo Company, and that in every sense it was a much more valuable property than their new cable could be, but that the shares of the Direct Company at the time I was speaking to them were at a discount of close upon 50 per cent. I pointed out that the company, if brought out, must of necessity come down to the same level, and that if they persisted in their scheme after this information the moment their cable was laid competition would arise, a 1s. or probably a 6d. tariff might be adopted, and although there might be a diminution in our receipts, it would entirely prevent the new company from paying one shilling to their shareholders, and the result we should look for would be that we should in time if we chose become possessed of their cable at least 50 per cent. cheaper than a new one would cost. I pointed out to them that there was no necessity whatever for the laying of a new cable, seeing that the existing cables were equal to three or four times the amount of work now offered, and seeing that the Anglo and Direct Companies have both applied the duplex principle, their carrying power had been very greatly increased. The result of the visit no doubt was to open the eyes of the financiers, and it must have caused them to hesitate; because they must have felt that it was clearly demonstrated that the real value in the market of similar property giving greater security was, as I have said, at nearly 50 per cent. discount. This was stated nearly three months ago, and they are wisely still hesitating—they need do so—for I need hardly say that responsible financial institutions floating a company with knowledge of the facts I have communicated brought home clearly to them, incur a grave responsibility which may be some day used against them. I was told that the *amour propre* of the French people must be satisfied, that the whole of this great telegraph enterprise centred in England—that France should share it, although France contributed only about 11 per cent. of Atlantic traffic. I have always held that submarine telegraphy should have an international character, and with that view, and in order to meet the French susceptibility, the Atlantic Companies were prepared to establish a company in France, with a French representation, using the Brest cable for the scheme to work in harmony with the existing systems. But there are contractors who must have work, and there are promoters who must, if possible, get a position and money out of such schemes. The contractors who are endeavouring to push it forward are the same who brought into existence the company over which I have the honour to preside, and who, I believe, had the changes not taken place that have been brought about by your Board, might, from their pecuniary claims as creditors have acquired the possession of the property. This I stated to you at the first meeting I addressed as chairman of this Company. The promoters of the new French scheme say they have got a concession from the French Government. It has been stated the head of the combination is to receive £20.000 for this concession with a permanent position as President of the company. I understand that the gentleman who is to manage the company is to secure for himself a remunerative position, and that the financiers, who are said to be backing it up, are to receive a very large amount of money other than what is required for the construction of the cables. Now, gentlemen, let us look for one moment at the amount that is going to pass into the hands of the promoters of this competitive scheme. As to the concession for which the £20,000 is to be paid, I may mention that there is already a concession from the French Government held by the Anglo Company which gives to them very important advantages with a preference of all the French traffic, and this concession has still eleven years to run. The arrangement is this—the Government agrees during a maximum period of twenty years, computed from the 1st of September, 1869, to forward by the concessionaire's line, but only on the condition of equality in rates, all official messages or private correspondence destined for the United States of North America for which the senders shall not indicate any route. That is a valuable concession, and is held at the present moment, and worked by the Anglo-American Company. I was anxious to obtain a sight of the new concession. I applied to the Government offices, but I found, for some reason or other, that although one of the leading Ministers told me he saw no reason why a copy of it should not be given us, as it was of the character of public utility, up to this moment we have

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not received a copy of this new concession. I was told, however, that it was merely a landing right, and that the French Government would be prepared to give such a concession to any respectable company who might ask for it. So that although £20,000 is to be paid for this particular concession, similar concessions might be had for the asking. Now, gentlemen, as to the promotion money. So far as I can learn the two cables for which they are asking subscriptions for upwards of £2,000,000 might be contracted for to-morrow for about £1,600,000, including the cost of laying, but allowing £100,000 for contingencies, there is a sum of close upon £400,000, the necessity for which it is very difficult to account. At all events, it is not going to be used in any way that can benefit telegraph enterprise. The promoters will, no doubt, be enriched, but it must be at the expense of the French subscribers. I am yet hopeful, however, that this scheme which I consider most unsound, will fail, as did its predecessor. Now, gentlemen, I come to another theme—that is our relations with the Governments and companies on the other side of the Atlantic. So far we have had no interference, no difficulty, of any kind, and our position, I believe, will be definitely recognised by the Canadian Parliament during the present Session. In the United States our traffic has been going on so satisfactorily that I have every reason to believe in the United States the Government are rather more disposed to encourage than to discourage telegraphic enterprise. Then, again, as to our land line connection in the United States we have come to a successful termination of our negotiations there. With the Dominion Company of Canada we are working under an old arrangement. We are negotiating for an extended agreement with that company which we are hopeful will be very soon completed, and when that is done we shall have a very satisfactory connection with Canada and the United States. You will observe an item in the account for the Duplex system. That system has now been successfully applied upon the cable. I should mention that any improvement in telegraphy, anything that will facilitate the carrying of messages or anything that will increase the value of our cable property that science could suggest, we are always ready to introduce and to give every suggestion aiming at that result, fair consideration. With these remarks, gentlemen, I beg to call your attention to another subject, and that is the question of debentures. As you are aware, when we took the management of this Company over we, in our first report, issued in November, 1877, stated that "It was intended by the directors to exercise as far as was necessary the power given to them by the aricles to issue £100,000 debentures from the proceeds of which they propose to pay off the outstanding 7 per cent. debentures issued by the old company, providing for the purchase of the interest of dissentient shareholders, and put the capital account on a firm basis, effecting at the same time an actual reduction of the share capital of the Company." We have paid off the 7 per cent. debentures. We are about to issue £100,000 of 5 per cent. debentures, which issue will be offered to the shareholders *pro rata*. The application of this £100,000 will be to recoup the amount that we have already paid off. It will also provide for the amount of money we have to pay the dissentient shareholders; so that, while it may appear to be increasing on the one hand it is decreasing on the other—I mean to say that we are going to replace with debentures the amount of shares we have to take up from the dissentient shareholders. Gentlemen: I am just reminded that this morning, or, rather, last night, we had a telegram to the effect that our main cable was mended, and that our traffic is going on as usual, and that the ship has gone to repair the shorter section. I may state at the same time—which is a repetition, because I believe you are all aware of it—that these interruptions, on account of our arrangements with the Anglo Company, do not in the least degree interfere with our revenue—that continues the same although the interruptions exist [cheers]. That is one of the very important features in submarine telegraphy, that, although one cable is an uncertain property, yet two or three are a valuable and secure property. With these remarks I beg to move "That the Report of the Directors, dated the 10th of March, 1879, together with the statement of accounts to the 31st of December, 1878, annexed thereto, be, and the same are, hereby received and adopted."—Mr. FORD seconded the resolution.

In reply to Mr. NEWTON,

The CHAIRMAN said: I will answer the last part of Mr. Newton's remarks first. I think I stated very plainly that it is the intention of the Board to offer the debentures to the shareholders *pro rata*. I have no doubt at all that such a security will be taken up by the shareholders, and I quite agree with him that we should not trouble the Stock Exchange, or any parties, if our own shareholders will take them up. The difference between 5 per cent. and 6 per cent. of course is considerable, but I think we may consider that the Company now is better security at 5 per cent. than it was formerly at 7 per cent., because it is backed by the Atlantic cables, which is a very great security, as I told you in the remarks which I have made. Although our cable was interrupted, our revenues were not interrupted, and I am very confident indeed that every shilling of those debentures will be taken up. The Eastern Telegraph Company has got money for 5 per cent., and I do not see why the Direct Cable Company should not do the same. I may mention also that although our main cable is mended the cable on Brown's Bank is still interrupted, but the ship has been ordered to repair it. The Anglo Company having changed the route of their Brown's Bank Cable about six months ago into shallower water, it is a question now whether the shallower or the deeper water is the safest for our cable. We are waiting to gather a little experience, and we shall repair the Brown's Bank section with as little delay as possible. But there is another consideration, and that is, whether we may not make such alterations as will reduce the interruptions in Brown's Bank to a minimum. You are aware that they arise from the fishing vessels who drop their anchors, and pick up our cable. If they cannot get rid of it they chop it, and the consequence is that we have had interruptions from that cause which otherwise would not have occurred; but the interruption of the short section of Brown's Bank does not interrupt our communication with New York, because we have the alternative land lines. As to the duplex it is £2,000 a year. We only pay it while the cable is working, and I may mention, although I do not wish to go into the figures just at this moment on the subject, I think at another time, when our cable is really in working order, I can satisfy even Mr. Newton, with all his desire for economy, that it is a very desirable thing to work the duplex principle. I would rather not go into the discussion of the matter now, because I believe there is a question pending whether our duplex system, or another duplex system, is the real duplex system, and as that may go into a court of law perhaps if I were to say what the advantages or disadvantages are it might be used against us in some way, and, therefore, I would rather not do so. If our system is proved to be the wrong system, or if the other system is proved not to be the original patent, it is quite possible that we may have the advantage of the duplex system without any payment at all; but, in the meantime, I do not wish to anticipate. I may mention at the same time that whenever anybody can come forward and show by any scientific instrument that we can double the traffic on our cable, I should welcome and remunerate him liberally.

In reply to Mr. WALKER and Mr. JACKSON,

The CHAIRMAN said: I am very glad indeed to hear Mr. Jackson's remarks as to the debentures, because I have no doubt at all, from Mr. Jackson's connection with submarine telegraphy, of the value of his opinion. He has always been a supporter of it, and I have no doubt at all that he will show his faith and belief in it by becoming one of the subscribers to those debentures. I have no doubt they will be floated. I believe it is very excellent security, and that there is no better in connection with submarine property than the debentures are. As to monopoly, I disclaim all desire for monopoly. As to the real question of submarine cables, I am quite satisfied that all those concessions which the American Government have been granting from time to time, limiting the tariff to a shilling, cannot be productive. Now, what have we done? We employ our lines during the active time of the day, and we charge a moderate amount. We are using that very carefully by accumulating a considerable reserve fund. But what do we do besides? In our spare time we give very valuable advantages to the Press—we give the Press quarter rates. That is an enormous boon to the public generally, because instead of getting short messages the Press are enabled now to fill columns with their telegraphic communications. We do it with very little profit or benefit to our shareholders; but it is an enormous benefit to the general reading public. I think altogether the principle on which we are endeavouring to carry on this property has been up to this time successful. I do not believe in competition in submarine telegraphy. I believe it would be destructive. If our cables do not pay; if we cannot put a reserve fund by and our cables part, where are we to get the money to lay fresh ones. Competition might bring us to that position. Therefore, I hope that those gentlemen in France who have endeavoured to get a big lump of money out of promoting these companies will realise the fact beforehand that I told one of the heads of these financial establishments—he was sitting at his desk. I said to him, now, sir, no man has a greater horror than I have of seeing money thrown away, but I tell you that in six months if you will make a memorandum of it now, the £2,000,000 of money that you are going to ask of the French public will only be worth a million in the market; so I think you ought to pause, if not for your own reputation, in the interests of the French people whom you are inviting to subscribe the money. I have given you rather a long story about the French affairs to-day. I did it for this reason. I have spoken plainly because I want it to go over to France, so that the French people may have the opportunity of seeing the view which the English shareholders take of the position of this concern.

The resolution was put to the meeting and carried unanimously.

A vote of thanks terminated the proceedings.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices March 26.		Business Done Week Ending March 26. Highest.		Lowest.	
Anglo-American	57⅛,	58⅛	58⅛		57⅛	
Do. "B"	86½,	87	87½		86½	
Do. "A"	29½,	30	29½		29	
Brazilian	6¼,	⅜	6 13-16		—	
Cuba	8,	⅛	—		—	
Do. Ten per Cent. Preference	15,	16	—		—	
Direct Spanish	1½,	2	—		—	
Do. Ten per Cent. Preference	10⅞,	11⅛	11⅛		11	
Direct United States	11 3-16, 5-16		11⅛		11⅛	
Eastern	7 7-16, 9-16		7⅝		7⅜	
Do. Six per Cent. Debenture	105,	108	—		—	
Do. Five per Cent. do.	100,	102	—		—	
Do. Six per Cent. Preference	11¼,	⅜	11⅜		11¼	
Eastern Extension	7 7-16, 9-16		7⅛		7 7-16	
Do. Six per Cent. Debenture	103,	109	107½		107	
German Union	7⅞,	8⅛	—		—	
Globe Telegraph and Trust	4 13-16, 15-16		5		4⅞	
Do. Six per Cent. Preference	10½,	⅛	10⅝		10⅛	
Great Northern	8⅛,	¼	8 3-16		—	
Indo-European	21,	22	21		—	
Mediterranean Extension	2⅛,	3⅛	3⅛		—	
Do. Eight per Cent. Preference	9⅛,	⅜	—		—	
Reuter's	9¼,	10⅛	10⅛		—	
Submarine	215,	225	—		—	
West India and Panama	1 11-16, 13-16		1 13-16		1⅛	
Do. Six per Cent. Preference	8⅜,	¼	8⅜		8⅜	
Western and Brazilian	3⅛,	4⅛	4 5-16		4	
West. Union Seven per Cent. 1st Mort.	114,	118	—		—	
Do. Six per Cent. Sterling	100,	102	101⅛		100⅛	

LECTURE ON THE ELECTRIC LIGHT.—A lecture was delivered last Tuesday by Mr. Harding, assisted by Mr. Hickley (the inventor of the Hickley Telephone), at the Staines Assembly Rooms. After some introductory remarks, in which the lecturer traced the history, theory, and progress of electric lighting, the electric light was shown by means of a powerful battery of 50 cells of Grove. For this purpose, Mr. Harding had provided a complete collection of electric lamps, which he explained in detail, showing the various advantages or disadvantages of the Werdermann, Farmer-Wallace, Jablochkoff, and Rapieff systems, &c., besides some of Mr. Hickley's improvements, one of which was guaranteed to give a steady light for upwards of 100 hours without requiring attention. Mr. Harding also showed an "Edison" lamp which he had constructed some years before Edison's patent was heard of. The value of the light for illumination under water was also exemplified by experiments, the lecture altogether being one of the most interesting and exhaustive we have ever had the pleasure of attending. Mr. John Ashby, of Staines, presided.

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NOTES.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—It is announced that the cable between Bahia and Rio Janeiro is repaired and that communication is thus restored.

NEW WORK ON THE ELECTRIC LIGHT.—We understand that Messrs. Spon will issue within a few days, a work written by Dr. Paget Higgs, treating the subject of electric lighting in a comprehensive manner.

SOUTH AFRICAN TELEGRAPHS.—We are, by the courtesy of Mr. Wood (the secretary of the Society of Arts), in possession of a proof of Mr. Sivewright's Paper on South African Telegraphs, which we hope to reprint in our next issue.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of March was 2,818, estimated to produce £3,100, against 2,924 messages, producing £3,517, in the corresponding month of last year.

EASTERN EXTENSION TELEGRAPH COMPANY.—A dividend for the quarter ended December 31 last of 2s. 6d. per share has been declared, making, with the previous interim distributions, 5 per cent. for the year 1878. To the reserve fund £44,112 has been placed, raising it to £75,017.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—Information has been received by the Cuba Submarine Telegraph Company (Limited), of the repair of their 1870 cable between Cienfuegos and Santiago-de-Cuba, thus restoring duplicate means of telegraphic communication with the West Indies.

EASTERN TELEGRAPH COMPANY.—The company announce the payment of an interim dividend of 2s. 6d. per share on the ordinary shares, in respect of profits for the quarter ended December 31, 1878. A dividend of 3s. per share on the 6 per cent. preference shares, less income-tax, for the quarter ended March 31, 1879, will be paid on the same date.

USE OF THE TELEPHONE ON GERMAN RAILWAYS.—Following the example of the Magdebourg-Halberstadt Railway Company, which has successfully employed the telephone on its line, the State railway authorities in Germany have invited their officers to make experimental trials with this instrument for the purpose of ascertaining how far it may be made available for the requirements of the service.

GREAT NORTHERN TELEGRAPH COMPANY.—The total receipts of this company for the year 1878 from all sources amounted to £218,692, the expenses to £61,557. The balance, after paying 5 per cent. dividend, has been appropriated to addition to reserve fund, to the pension fund of the staff, to remuneration of directors, and for an extra dividend of 2s. 9d. per share. The balance carried forward is £14,837.

FOUR LECTURES ON ELECTRIC INDUCTION.—We are glad to inform our readers that Mr. Gordon has determined to issue these lectures in book form, and that the work will be published immediately by Messrs. Sampson Low and Co. The question of electric induction is a very important one, and not understood so well as it should be, and we trust that any effort to throw light upon the subject will obtain the consideration it deserves.

A TELEGRAPHIC FEAT.—On Friday, the 28th ult., between eleven o'clock and noon, no fewer than 215 messages, averaging thirty words each, were disposed of on a single wire—London and Birmingham—by means of the Quadruplex. The number, we believe, is unprecedented in the history of telegraphy, and we think it right to publish the names of the clerks whose individual skill must have greatly contributed to the result:—Mr. Howson sent fifty-four messages, Mr. Kemp sent forty-seven messages, Mr. Mitchell received fifty-two messages, Mr. Riley received sixty-two messages; total 215. We regret that we are at present unacquainted with the names of the operators at the other end of the line.

FRENCH POSTAL AND TELEGRAPHIC RECEIPTS IN 1878.—At the period of the reduction of the tariffs a loss was anticipated of 18 millions of francs in the postal receipts and 1·2 millions on the telegraphs, or 19,200,000 francs altogether for the first year of the reduction. We are happy to state, however, that, according to the returns for the first eight months of the above year, the falling off in the receipts during that period was but 6,190,690 francs, instead of the anticipated *pro rata* sum of 12·8 millions. These figures justify the expectation that, within a comparatively short period, the receipts of this department will rise to their former figure; and this in spite of a most beneficial reduction, amounting to 20 per cent., on the postal charges, and to more than 30 per cent. on those made for the transmission of telegrams.

ANOTHER STARTLING INVENTION.—An American contemporary announces a new discovery in telegraphy so stupendously incredible that we should not refer to it but for the fact that the newspapers in this country are beginning to discuss it in all seriousness. The rumour comes with the usual circumstantiality characteristic of "inventions" from America. A New York Cable Company has just secured the exclusive right to the use of an electrical discovery wherewith at least 200, and as many as 2,000 words a minute can be signalled through a submarine wire. There is the further statement that the Anglo Company tried to buy—in other words burke—the invention for £400,000. Happily (for the Anglo shareholders) this sinister attempt was frustrated; and the New York Cable Company have secured a monopoly for themselves, of course with the benevolent intention of giving it to the world. There is some "great invention," no doubt, at the bottom of all this; but we suspect that it is of the journalistic sort.

ELECTRIC LIGHTING AT THE ROYAL ALBERT HALL.—The following curious letter has appeared in *The Times*:—"I wish to enter my protest in *The Times* against the proceedings of the Royal Albert Hall Corporation in the matter of the electric lighting of that building. As an original seatholder, I object strongly to pay £2 annually on each stall for the current expenses. This is, however, in accordance with the terms of Lord Redesdale's Act of 1876, and it is not, perhaps, sufficiently known that the Corporation has power, under that somewhat tyrannical measure, to mulct us to the

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extent of £10 per seat in each year. In the accounts recently issued, I find that the sum of £600 is put down as the estimated cost of the electrical lighting, which I am confident no seat-holder really desired, and which I am equally sure most are agreed to declare a very ghastly and unpleasant innovation. The seat-holders have had no voice in this matter, and it seems only fair that their views may be made known. For my part, I consider the whole proceeding both high-handed and quite unnecessary."

On the Electric Light applied to Lighthouse Illumination, by Mr. J. N. Douglass, M. Inst. C.E.—In this Paper, referred to in our "Notes" last week, the author showed the progress of lighthouse luminaries from wood and coal fires to the introduction of tallow candles, fatty oils, mineral oils, coal gas, and electricity. In 1839 experiments were made by Faraday, for the Trinity House, at the Orford Low Lighthouse, with the Bude light, and, in 1862, at the South Foreland with the Drummond or limelight; but the results were not so satisfactory as to lead to their adoption. In 1857 experiments were tried at Blackwall with the electric light, produced by the first magneto-electric machine of Holmes; and on the 8th of December, 1858, the electric light, obtained by Holmes' second machine and a "Duboscq" lamp, was shown on the sea for the first time from the South Foreland High Lighthouse. On the 1st February, 1862, the Trinity House exhibited the electric light permanently at Dungeness Lighthouse, by Holmes' magneto-electric machines and lamps. The works for the production of the light were described, and the first cost and maintenance given. The intensity of the electric luminary was about 12½ times that of the oil luminary. The cost per unit of light per hour was 0·1165d. for the oil, and 0·1294d. for the electric light. Frequently falling off of the latter light occurred, and the oil light had occasionally to be substituted. Shortly afterwards the French lighthouse authorities established the electric light at Cape La Hêve, with the magneto-electric machines of the Alliance Company of Paris. In 1867, Holmes further improved his machine and lamp. Two of these machines and lamps were exhibited by the Trinity House at the Paris Exhibition of 1867, with a dioptric apparatus of the third order. The Souter Point Lighthouse was lighted by electricity in January, 1871. The light was adapted to a dioptric apparatus of the third order. A lower light from the same luminary as the upper one was adopted here for the first time. The optical apparatus for both lights was designed by Mr. James T. Chance, M.A., Assoc. Inst. C.E. A "Holmes" fog trumpet apparatus was also worked from the same engines as the electric light apparatus. The total cost of the works was £18,000. The cost of the electric luminary per candle per hour was 0·056d., being rather less than half of the cost per unit at Dungeness. The maximum intensity of the beam from this apparatus was about 700,000 candles. The Trinity House next established the electric light at the South Foreland High and Low Lighthouses, in January, 1872. The apparatus for the production of the light consisted of two steam engines of 20 effective horse-power, four Holmes' improved magneto-electric machines and lamps, and two dioptric apparatuses of the third order for fixed white light. The cost of the additional works for these lights was £14,800. The intensity of the full power beam from the High Lighthouse was about twenty times that of the old first order dioptric oil light. The relative cost per unit of light was as 100 oil to 30·6 electric. In 1873, the Trinity House adopted, for the Lizard Lighthouses, Siemens' dynamo-electric machine and lamp, and a siren fog signal. These were driven by three of Brown's caloric engines, each of 10 effective horse-power. The cost of the additional works for these lights was £14,936, and the annual maintenance, including interest on first cost, amounted to £2,365 6s. 4d. against £1,016 7s. 11d. for the oil lights. The intensity of the full power beam of each light was about 330,000 candles, being about 211½ times the intensity of the oil light. The relative cost per unit of light was 100 oil to 14·04 electric. The successive improvements in the electric machines and in the means of driving them had reduced the cost of the electric light at the Lizard to one-ninth of that at Dungeness, and the quantity of light produced at the Lizard per pound of coke consumed was increased 20 times. The continued growth seaward of the shingle point at Dungeness led to the removal, in 1876, of the original electric light apparatus, and the substitution of a low flashing oil light and siren fog signal for both lighthouses. The author furnished information received from M. Allard, Director-General of the French Lighthouses, relative to the electric lighthouses at Cape La Hêve and Cape Grisnez, where Alliance magneto-electric machines and Serrin lamps had been adopted. It was intended to exhibit the electric light in the present year in a new lighthouse on the Isle of Planier, opposite Marseilles, and it had been decided to substitute the electric light for the oil light in the Palmyre Lighthouse at the mouth of the Gironde. The comparative cost and efficiency were shown of lighthouse luminaries produced by all the agents at present employed, viz., oil, coal, gas, and electricity. Coal gas, on Wigham's system, was applied to the Howth Bailey Lighthouse, Dublin Bay, by the Commissioners of Irish Lights in June, 1865, and it had since been extended to seven lighthouses on the coast of Ireland. In 1872 the Trinity House adopted it at the Haisborough High Lighthouse. The additional cost of the works necessary for the introduction of gas at this station was £1,996, and the annual maintenance of the gas establishment, including interest on first cost, &c., amounted to £832 4s. 3d. This light had a mean intensity of 1,173 candles, and a maximum intensity for thick weather of about 2,923 candles. In 1877 the necessary additions were made for lighting the Low Lighthouse—distant 766 yards—by gas from the same works at a cost of £1,296. The system of Mr. Wigham had been further developed by introducing the flames of two, three, and four large burners over each other in the axis of the dioptric apparatus. In January of last year the Commissioners of Irish Lights adopted one of the latter lights in a new lighthouse at Galley Head, near Kinsale. The maximum intensity of the four burners combined for thick weather was about 5,012 candles. The author next gave statements, showing the comparative focussing compactness of the lighthouse luminaries which had been referred to for utilising in optical apparatus, viz., the lights produced by oil, coal gas, and electricity. The focussing superiority of the electric luminary, compared with the best of these, was as 616 to 1. Statements were given of the comparative average cost and annual maintenance of a single lighthouse—shore station in this country, with colza oil, mineral oil, coal gas, and electricity, as the illuminating agents, both with and without a first-class 20 horse-power siren fog signal. For a maximum degree of light equal to the single or combined intensity of the luminaries of the Lizard, the cost of the more perfect electric luminary per unit of light provided was about 13-22 and 6-22 respectively of that of coal gas, and about 13-65 and 6-65 respectively of that of mineral oil, at their maximum intensities. With higher intensities of the electric luminary the cost per unit would be more in its favour, no further addition to the working staff being necessary.

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ELECTROSTATIC POTENTIAL.

It has only been after long labour and thought that I have gained for myself what I consider a tolerably clear conception of the potential, gravitational or electrostatic, of a body, and, as I find that my own difficulties confront each one of my pupils, and may, therefore, beset others, an elementary consideration of the subject may be useful to some of your readers.

It is an experimental fact that we have to expend work in order to move an electrified body X from one position to another in presence of an electrified body Y, gain of work being considered a negative expenditure; but this work has not to be done if Y is unelectrified. Hence a body acquires, by electrification, the property of requiring work to be done when an electrified body is moved in its presence. It is this *property* of an electrified body which is termed its electrostatic potential.

This property is, further, a measurable quantity, as more or less work is done according to the circumstances, and it may, therefore, be expressed in terms of the work done and the electricity on the moved body. Now, it is easy to show that the work done in bringing one electrified body up to another electrified body from an infinite distance is independent of the path by which it is brought up, the distribution of electricity on both the bodies being supposed unaltered during their change of relative position—a condition which is sensibly satisfied if the dimensions and the charge of one of the bodies are very small. In fact, let w be the work done in bringing up a charged particle from rest at an infinitely distant point A, by any path A B, to rest at a point B on the charged body. If the particle is now moved along the surface of the body to another point C, where it is brought to rest, no work will be done in the process, as the electric force at all points of the surface is normal to it (otherwise the electricity could not be in equilibrium on the surface). Thirdly, let w' be the work gained by allowing the particle to move away by any path C D, and bringing it to rest at an infinitely distant point D. If, lastly, the particle is moved by any path, every point of which is infinitely distant from the charged body, to rest at A, no work will be done in the process, since at infinitely distant points the electric force is zero.* Everything is now exactly as it was at first, and therefore, by the law of the Conservation of Energy, there can have been neither loss nor gain of energy, so that $w' = w$; or, as w' will equal the work done in bringing the particle along the reverse path D C, the work done in moving the particle by *any* path whatever from *any* point at an infinite distance to the charged body is the same. From this we can deduce a perfectly definite mode of measuring the electrostatic potential of a body, and we *measure* it by the work done *per* unit of positive electricity on a charged particle that is brought up to the body from an infinite distance, the distribution of electricity on the bodies remaining unaltered during the motion. A body is thus at unit potential when unit work has to be done in bringing up to it from an infinite distance a particle charged with unit positive electricity.

The dimensions of electrostatic potential can be at once found, for, as it is measured by work per electricity, they are $\frac{W}{E}$, where W and E are the dimensions of work and electricity respectively; but $W = M L^2 T^{-2}$, since work is space, L, into force, and force is mass, M, into acceleration, $\frac{L}{T^2}$; and $E = M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-1}$, since, unit electricity being that quantity which repels an equal amount at unit distance with unit force, the repulsion between two particles separated by distance r and charged with e and e' units of electricity respectively is $\frac{ee'}{r^2}$ by Coulomb's law, that is, of dimensions $\frac{E^2}{L^2}$, which are thus those of force $M L T^{-2}$, so that $E^2 = M L^3 T^{-2}$; hence the dimensions of electrostatic potential are $M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-1}$, which, for ease of remembrance, we may notice are those of $\sqrt{\text{force}}$.

I wish it to be particularly noticed that, in the above, electrostatic potential is defined as a particular *property* of a body which is *measured* in a particular way. I think that the main difficulty which besets a learner, and throws his mind into utter chaos on this subject, arises from the fact that the measure of potential is generally given as its definition, especially in mathematical books. This is the case, for instance, in Thomson and Tait's "Natural Philosophy," §§ 485, 486, 491, &c.; in Clerk Maxwell's "Electricity and Magnetism," §§ 70, 71; and in Cumming's "Theory of Electricity," §§ 35, 62, Professor Maxwell's words being "The potential at a point *is* the work which would be done on a unit, &c.," so that potential is work, and therefore of dimensions $M L^2 T^{-2}$; for there cannot be any difference in kind between the work done on one unit and the work done on fifty units. And yet we are also told that the dimensions of electrostatic potential are $M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-1}$! It is soothing to read in Fleeming Jenkin's "Electricity and Magnetism," p. 26, "Difference of potentials is a difference of electrical condition in virtue of which work is done . . . , and it is measured by the amount of work done, &c." Of course, the other writers mean this, but, as they do not say it, a student becomes utterly confused. I think electrostatic potential should be defined entirely apart from its mode of measurement, for it exists whether we can measure it or not.

Equally loose expressions are to be found in our text books. Thus in Cumming's "Electricity," § 10, we read: "The density of a given substance is defined as the amount of matter in a unit of volume." We might just as well say that the velocity of a body *is* the space it traverses in a second, whereas it really is the condition of the body whereby it traverses space, being *measured* by the space traversed *per* second. Our text-book definitions want regular overhauling.

The presence of a charged body causes work to be spent in bringing an electrified particle from an infinite distance to a point in its electric field, *i.e.*, in the region wherein it exerts electric action, and, by a mode of demonstration similar to that given above (which is due to Professor Clifton), it can be easily shown that this work is independent of the path, and so dependent on the charged body and the position of the point only. The result is thus just the same as if there were at the point a body charged to the electrostatic potential which is measured by the work done per unit of positive electricity on the particle that is brought up to it from an infinite distance, and this electrostatic potential is, for shortness, termed the electrostatic potential *at* the point. Hence the electrostatic potential at a point is that of a body which, being placed at the point, would cause the same amount of work to be spent in bringing up to it from an infinite distance a charged particle.

The work done in bringing up a particle A', charged with e' units of electricity, from an infinite distance to a point P at a distance r from a particle A, charged with e units of electricity, is

$$-\int_{\infty}^{r} \frac{ee'}{r^2}\, dr = \frac{ee'}{r} \text{ work-units,}$$

and thus the electrostatic potential of P is $\frac{e}{r}$ potential-units, the particle A' requiring $\frac{e}{r}$ work-units to be spent in bringing it up to P for each unit of electricity with which it is charged. We can show this elementarily in an indirect manner. Thus, assume that the potential at P, a point distant r from A, is $\frac{e}{r}$; then at a point Q, which is distant $r + r'$ from A along the line A P, the potential will be $\frac{e}{r + r'}$. Hence the work done in bringing up the particle A' from an infinite distance to Q and P will be $\frac{e e'}{r + r'}$ and $\frac{ee'}{r}$ respectively, and, therefore, in moving it from Q to P, the work done will be

$$\frac{ee'}{r} - \frac{e e'}{r + r'} = \frac{e e' r'}{r(r + r')}.$$

Thus, as the distance Q P is r', the mean force of repulsion of A upon A' at the points between P and Q will be $\frac{e e'}{r(r + r')}$, and this is equal to $\frac{ee'}{r^2}$, if r' is so small that Q practically coincides with P, in which case the last expression must denote the repulsion when A' is at either P or Q. As we know that it does represent this force, we conclude that our premiss—that $\frac{e}{r}$ is the potential at P—is correct. This reasoning really gives $\frac{e}{r}$ + const. as the potential at a point; the constant must, however, be zero, as the potential at an infinitely distant point is zero. The unit of potential is that given above.

Of course, if work is gained, instead of being lost, in bringing up our positively charged particle from an infinite distance, the body must act attractively or be charged negatively, and its potential is negative.

I think scientific exactness requires us to discontinue the use of the term *tension* to denote the property which is above termed *potential*, for the former is now used so very loosely, with so many different meanings—thus, the tension of a string is the whole force acting along it, the tension of a stretched surface is

* More exactly: of whatever order of infinity is the length of the path, the electric force is an infinitesimal of twice as high an order, so that their product is infinitely small.

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said to be the force acting across unit length of a line in the surface, and the tension of a gas is said to be the force acting on unit area of its containing envelope, the dimensions of the tensions in these several cases being MLT^{-2}, MT^{-2}, $ML^{-1}T^{-2}$ respectively—and in no case those of potential, so that they are essentially different in kind. As we have now succeeded in assigning to the term *force* a definite meaning, so let us reserve *tension* to express some one definite thing, and if we define it as that property which is measured by the force exerted per unit area, then there is perfect propriety in saying that the electric tension at any point of a body is measured by the repulsion of the electricity on unit area about the point; and this definition of tension fits in best with mechanical analogies. Thus, while the electrostatic potential is the same at all points of a conductor in equilibrium, the electric tension may vary very considerably.

In one of the letters on the subject of potential in *The Electrician* (p. 199) I read a quotation, "The capacity of a sphere in space is simply the radius." I never saw this statement before, and do not wonder at the incredulity of those who have met with it. A few words may not be amiss on this point.

It is experimentally found that the potential of a body charged with a definite amount of electricity varies according to its position with regard to other bodies. Hence, according to its position, it requires different amounts of electricity to acquire a given potential, and this *property* is called its electrostatic capacity, and it is *measured* by the electricity that is communicated to the body per unit of potential to which it is brought. If E and V are the dimensions of electricity and potential respectively, its dimensions are, therefore, $\frac{E}{V}$ or L by our fourth paragraph. The unit of capacity is the capacity of that body which requires unit electricity to bring it to unit potential, and a body has $\frac{e}{v}$ capacity-units if it requires e electricity-units to give it v potential-units. If the body is an isolated sphere of radius r, the potential at its centre, which is distant r length-units from the electricity (as the latter resides on the surface), is $\frac{e}{r}$ potential-units; but this is r, since the potential at every point of a conductor in equilibrium is the same. Hence the electrostatic capacity of an isolated sphere of radius r length-units is $\frac{e}{v}$ or r capacity-units.

Further, we know that, if two bodies at different potentials are connected together by a conductor, their potentials alter till they become the same. This can only occur by the transference of electricity from one body to the other, and this *phenomenon* of transference is called an electric current, and its strength is *measured* by the amount of electricity transferred *per* unit time, so that its electrostatic dimensions are $\frac{E}{T}$, or $M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-2}$.

In actual practice, such as telegraphic operations, measurements are made by noting the deflexions of a magnetised needle, and it is, therefore, convenient to choose a different unit of electricity to that we have taken above. But this change of units does not interfere, in the slightest degree, with the definitions and modes of measurement of the potential, tension, capacity, and current. Their dimensions only are altered. We first of all take, as unit of magnetism, that amount which repels an equal amount at unit distance with unit force, and Coulomb's law gives us, as before for electricity, its dimensions as $M^{\frac{1}{2}} L^{\frac{3}{2}} T^{-1}$. Next we observe that an electric current can deflect a magnetic needle, and we therefore choose for unit current that current of which unit length would exert upon a magnetic pole exactly the same force as a unit magnetic pole put in its place. Thus, the force exerted by a length a of a current of intensity i on a magnetic pole of intensity m at a distance r is $\frac{mai}{r^2}$, and is, therefore, of dimensions $\mu I L^{-1}$ (where μ is the dimensions of magnetism), or $I M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-1}$; but, being force, it has dimensions MLT^{-2}. Hence, equating these expressions, we find $M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-1}$ (or $\sqrt{\text{force}}$) for the dimensions of the intensity on the electro-magnetic system. The unit of electricity is then taken as the amount of electricity that passes across a given section in unit time when a current of unit strength flows in a conductor. Its electro-magnetic dimensions are, therefore, IT or $M^{\frac{1}{2}} L^{\frac{1}{2}}$. Finally, the dimensions of potential being $V = \frac{W}{E}$, they are $M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-2}$, and the dimensions of capacity, being $C = \frac{E}{V}$, are $L^{-1} T^2$.

The practical units of potential, capacity, and resistance are the Volt, Farad, and Ohm, which are respectively 10^8, 10^{-9}, 10^9 times as great as the absolute electro-magnetic units just described, when the gram, centimetre, and second are taken as the fundamental units. The quantity which raises by one volt the potential of a body whose capacity is one farad is called a Weber,* and is thus one-tenth of the absolute electro-magnetic unit of electricity. The work done in bringing up a particle charged with a weber from an infinite distance to a body charged to a potential of one volt would be 10^7 ergs, or 10 megalergs; and the current measured by a weber per second, which is produced in a conductor by a difference of potential at its ends equal to a volt for every ohm of resistance, is one-tenth of the absolute electro-magnetic unit of current.

Fleeming Jenkin, in his "Electricity and Magnetism," pp. 160, 161, speaks of the practical unit of electricity (the weber) as a farad, and, for brevity, terms the practical unit of current also a farad. Such terminology introduces the gravest difficulty and confusion into a subject already sufficiently difficult. A farad is capacity, and capacity only, and none but the most inaccurate use the expression which is cited to justify the brevity. As force is measured by the number of ergs of work done per centimetre, we might as well term the unit force an erg, omitting *per centimetre* for shortness.

I said above that a definite meaning is now attached to the word *force*. I should have said, with one exception; for the numerator of the fraction in the expression of Ohm's law is still termed *electromotive force*, though it partakes in nothing of the nature of force. This term belongs to a bygone age, when the word *force* was applied to anything and to everything; but a scientific age has discovered that it denotes a difference of potential, and should, therefore, substitute some such expression as *potential-difference* for it. Cannot *The Electrician* lend its countenance and support to such a change, especially as there does actually exist a real force which sets the electricity of a current in motion, and has, therefore, a strong claim to the title of electromotive force?

ROBERT E. BAYNES.

Christ Church, Oxford, March 20, 1879.

MAGNETIC MOTORS.

Considerable temporary excitement has been elicited, both in this country and in America, by the announcement of the invention of a new motor. This motor was said to be founded upon "an entirely new principle in magnetism." Those most knowing in the science of magnetism are well aware how small is the amount of definite knowledge in what is vulgarly regarded as a well-known subject. Hence curiosity was not limited to those of the public whose chief claim to be considered as supporters of science is subscription to technical literature, but was shared alike by more learned contributors who constitute the sum, the total of which is known as the scientific world. All striking inventions emanating from our relatives on the other side of the Atlantic, that are not authenticated to common vision, are somewhat justly considered *cum grano salis*. This does not arise from innate unsubstantiality in transatlantic ideas, but, from a sequence of deduction in the commercial mind that is perfectly natural. Anyone acquainted with the comparative easy introduction to the notice of capitalists possessed by an inventor native to and resident in the United States, naturally asks why an invention that has not sought introduction in the American market should be produced here. American mechanics are probably without rival in the world, and American perception of "a good notion" is as quick as that of most other nations. With the simple patent laws existing in the States, there is, therefore, ample ground for the prejudice existing against "notions" untried on their native soil.

We learn from our own patent office that provisional protection was awarded to Miss Harriet Hosmer for her invention in the production of motive power by means of a new principle in magnetism. Mr. Gary, also an American, claims a similar idea. Miss Hosmer, as a sculptress, is not unknown to fame, and it must be said that the idea she has sought to embody as a mechanical fact, is most seductive. The invention is described as founded on a new principle in magnetism, but is really dependent upon conditions underlying an experiment untried by few schoolboys. A common magnet supports so many nails, or so much iron filings; the application of the keeper or armature causes these to fall off. Now, if we can only apply the armature automatically, we have within our grasp an approximation to the long sought *perpetuum mobile*. In the invention due to Miss Hosmer, this idea is carried out under scientific principles more theoretically near perfection than those of her male competitor. We say this with diffidence, because we are afraid that our assertion may be misunderstood by those interested in universal suffrage. A heavy flywheel, mounted with as near an

* I must here protest against the horrid barbarism *veber*; let us have either the German *weber* or the anglicised *vayber*, but not the hybrid *veber*.

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approach to frictionless bearings as possible, carries in its hub a series of keepers or armatures, presented to a corresponding series of fixed magnets, in such a manner that magnetic attraction is never satisfied. That is, just as a keeper is passing a magnet the poles of the magnet are rendered inactive by a secondary keeper being placed upon them, which is subsequently removed by the movement consequent upon a momentum of the heavy flywheel. Mr. Gary's motor is based upon similar principles, but actual contact is avoided, the annulling of magnetic attraction depending upon presentation to the magnet poles of sufficiently large masses of soft iron. In each case the inventor has succeeded in constructing a scientific toy, bearing about as much relation to practical development of motor power as Bohrenberger's electroscope, in which a gold leaf oscillates between two oppositely-charged electric poles, does to the steam engine. In the first place, anyone who has succeeded in making magnets from a so-called permanent magnet, knows that the limit to the number of magnets he may make is comparatively small, large as it may appear if the primary magnet is allowed to recover its power from the contrary attraction of terrestrial magnetism. Magnetic power, although not strictly reducible to the exact laws found to exist for other manifestations of conservation of energy, is, we know, still amenable to the same law; and, consequently, constant succession of presentation to each other of magnets of similar polarity must eventually reduce this power to *nil*. On the second point, energy or work is commeasurable by the foot-pound or foot-ton, and as magnetic power is available through only very short distances, it is obvious that, practically, immense weights would have to be given to the moving magnetic masses. This we know to be unattainable by present means. Besides, the attractive power is limited to magnetic saturation of steel, and this, from Professor Everett's reliable tables, it does not need a mathematical consideration to show, is within very small limits as regards the energy compared with that of gravitation or that from the combustion of coal.

These two inventions are well worthy of the consideration we have given them, because they are dangerous fallacies, likely to lead even thinking men astray whose thought is not founded on sufficient reading. Inherent substantial merit the inventions have none; we have simply sought to raise a sign-post of warning.

PAGET HIGGS, Assoc. Memb. Inst. C.E.

THE ELECTRIC LIGHT AT THE SEVERN BRIDGE.

The following is an abstract of the electrician's (Mr. W. Brain) report of the electric light at the Severn Bridge :—

The Light.—The apparatus is erected in duplicate, both with regard to the generators (as they may be termed) and the lamps; but so arranged that either lamp may be lighted from either of the dynamo machines, or from the same machine, and changed as often as the men in charge please from lamp to lamp, or the same lamp during its burning changed to and from either machine. This arrangement is effected by two small neat switches standing back to back opposite four connecting plates, under which the ends of the cables are secured in metallic connection. For bridge work it is absolutely necessary to give a constant and steady light, because should the lamp flicker or the light go out, several of the men's lives may be placed in a very hazardous position; consequently, every care has been taken to design and carry out an arrangement that has proved to be equal to the requirements of the case. The one lamp is a Serrin, arranged so that the carbons can work inside a parabolic reflector, to which is attached an oblong, flat zinc screen, so that the rays are not only concentrated on the work, but at the same time prevented from being an annoyance or source of attraction to the shipping going up or down the river above or below the bridge. A reflector and screen of this description was designed and kindly lent for the experimental trial by Mr. Robert Gray, of the India Rubber and Gutta Percha Company, Silvertown. The other lamp is that of Siemens.

The Machines or Generators.—The dynamo machines are, one of Siemens's small size, running at 1,050 to 1,100 revolutions per minute, and doing its work remarkably well, keeping perfectly cool, and showing scarcely any fire on the brushes of the commutators. The other dynamo is a Gramme A size, made at Silvertown by the India Rubber and Gutta Percha Company, making 850 revolutions per minute, and giving equally as good results as the Siemens, but a higher electromotive force (or, in other words, greater intensity of current), and showing no spark or fire on the commutator brushes. Both the dynamos are driven by a small portable engine of 8 horse-power, which is fitted with a very sensitive governor. The engine stands on a platform erected about midway, and between four of the iron pillars or columns which carry the bridge, and immediately above the engine is a small cabin, in which the dynamo-machines are fixed. The total length of cable is 350 yards. The lamps can be used, one on each side of the span to be erected, or both on one side, whichever suits the work in hand *pro tem* best. After the machines are erected, cable laid, &c., it is necessary to set the brushes of the machines so as to give the minimum of spark. This operation requires delicate manipulation and care, especially with the Siemens machine, but the engineer having had two years' experience with this machine, has found a ready method of teaching the man in charge, which is simply to take the exact measurements of the length of the brushes from the studs that hold them, and mark the exact position of the point of each brush and the sliding frame that carries them. This is done as soon as the brushes are set in that position which gives the maximum light the lamp is capable of, and when no fire is visible between the brushes and the commutators, and the coils remain cool, or only slightly warm. The reasons for erecting the lighting apparatus at the bridge are as follows :—First, there are only a few hours between each tide that the men can work, and these hours sometimes occur in the middle of the night, or when it is very dark, or, it may be, very foggy. Secondly, it is very essential that all speed should be made in completing the bridge. The capital already expended is very great, nearly £200,000, and the daily interest of that sum will soon pay for adopting the electric light to assist in finishing the structure. Thirdly, the protection of life to the workmen. The men are placed in a position to do their work, which, notwithstanding every care taken, and the anxiety and forethought constantly exhibited by Mr. J. Earl (under whose superintendence the contract is being carried out) is not one free from danger nor within the ordinary risk of common work, but now that they are working in a light the nearest approach to the noonday sun which science and skill can produce, the dangers, if not entirely removed, are reduced to a minimum. Fourthly, the benefit of the neighbourhood.

The report then goes on to show the great advantage of employing men who take an interest in their work, speaking very highly of the man in charge of the electric apparatus. The lighting is carried out by the Pyramid Electric Light Company.

EXPERIMENTS WITH THE ELECTRIC LIGHT AT MESSRS. RANSOMES, SIMS, AND HEAD, IPSWICH.—Some interesting experiments with the electric light have been made at the Orwell Works. The success achieved by Messrs. Ransomes, Sims, and Head with their patent governor for securing regularity in the running of engines for generating electricity has gained them a wide reputation, and they are just now executing an order for four engines and machines combined for the Indian Electric Light Company for use in India. For electric lighting one of the greatest difficulties to contend against was the necessity for regularity in speed, and to secure this Messrs. Ransomes adapted their patent automatic governor expansion gear, which regulates the movement of the engine to such a nicety that the revolutions remain without any perceptible fluctuations. It is of great importance to use a separate engine for each light, and Messrs. Ransomes have adapted four 6 horse-power engines for the Indian company. The electric apparatus is carried on a platform extending beyond the smoke-box of the engine, so that the whole of the machinery, motive power, and electric generating and distributing, is self-contained, and the engines being portable, they are readily transported from place to place. Gramme machines and Jablochkoff bougies are employed. Each candle is equal to about 600 sperm candles, and six lights can be kept burning by one engine. To produce the light, the exciter machines make 1,200 revolutions per minute, and the divider 1,100. The arrangement for carrying the electric machines was designed by Messrs. Ransomes, and the plan adopted is simple and effectual. The platform rests upon an arch of iron, firmly fixed to the engine; and to secure perfect tension of the driving strap, the machines are placed upon a sliding table, worked by means of a screw, which enables the man in charge to regulate them to the most exact nicety. This apparatus is constructed from the designs of M. Dollfus, engineer to the Indian Electric Light Company, who personally conducted the experiments. At the trial on Monday the painting shop at the Orwell Works was lighted by six of the Jablochkoff candles, and was never lighter during the brightest summer day. The building is 126ft. long by 24ft. wide, and is ordinarily lighted by eighteen gas jets from the roof, which, it is needless to say, were quite eclipsed by the brilliant and steady light produced by the engine. Though six candles were used on Monday, three would be amply sufficient for lighting such a space. This marks a further stride towards the development of the electric light, and we heartily congratulate the Messrs. Ransomes on being the means of affording an additional proof of its utility for illuminating purposes.

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W. LASCELLES SCOTT.—Will our contributor forward his present address, as we have received a letter intended for him.

OVERLAND *VERSUS* SUBMARINE.

That passion for opening up fresh country, which takes hold of the British colonist just when he might begin to settle down, often tempts him to strange ventures. Our brethren at the Cape, with proper English masterfulness, consider every acre of the Dark Continent, no doubt, as potentially their own. We are not inclined to dispute the pretension, but we may take exception to the way in which they propose to further it. They are sorely in want of telegraphic communication with the rest of the world; they wish to establish it themselves, and in their own way; but it happens that theirs is the way which nobody, without ulterior aims, would have chosen. The colonists avow, in fact, their desire to humanise, civilise, and missionise the native African races, and to do a stroke of business at the same time. This has long been the intent of their hearts; and fortune, in the shape of the Home Government, seemed, for a moment, likely to gratify it. Mr. Sivewright was sent out nominally as manager of the Cape telegraphs; but, being a man of enterprise, of large ideas, and superabundant energy, he quickly fell in with the prevalent aspirations of his new friends, and devised for them—or, at all events, countenanced—a scheme of overland telegraph, which, short of striking right across country and coming out facing Gibraltar, was likely to satisfy their loftiest ambitions. Some 2,000 miles had to be traversed; the wire was to be in sections of, if possible, no greater length than 400 miles. If there chanced to be habitable places at such convenient distances so much the better; if not, then the wire would, doubtless, make them habitable. One or two fairly suitable countries do exist northwards along the Eastern shore, and a sanguine temperament was not to be deterred by the mysterious and impracticable reputation of the regions between and beyond. When, therefore, Mr. Sivewright, with a manner as Colonial as if he had been born to it, talked of "striking a blow at that inhumanity which prevails in the weird Continent, and makes countless thousands mourn," the programme was irresistable, and the projected land wire was as good as started.

But events are stronger than arguments; and it so befel that on the very day this proposal was being publicly discussed here in England, the Home Government, in secret Council assembled, decided in favour of a submarine cable. That the decision was a right one appeared pretty evident by the reception which this rival scheme from the Colony met with at the Society of Telegraph Engineers on Wednesday last. The members of this Society are an intensely matter of fact body of men. The humanitarian side of the question was not so much as mentioned by them; and as to "opening up fresh country," the notion sounded probably to their unromantic ears like a hen trying to hatch eggs which she has not yet succeeded in laying. You cannot build a house by putting up gas fittings; and although the telegraph is great at developing resources, it does not usually create them out of nothing. Such seemed to be the sentiments of the gentlemen who discussed Mr. Sivewright's Paper, far removed from the local influences which gave rise to it. The issue was plain. A cable could be laid quickly, and would last a number of years; whether a land line could be constructed at all was problematical; in any case it would advance very slowly; and its maintenance would always be a matter of uncertainty. Such portions of the route as were known were declared to be, as regards obstructions, altogether unique. Patience and pluck would make a pathway; but Nature would defy all efforts to keep it clear; and there was a general concurrence of testimony that though you might erect your poles you would never find them again amidst the entanglement of a gigantic undergrowth, as rapid as Jack's beanstalk and almost as tall.

These dawbacks on the score of time and construction were, strange to say, taken no account of by the Colonists. The telegraph has been carried through thousands of miles of prairie and across deserts elsewhere; it exists in security by the side of the Indian's wigwam, and the tent of the warlike

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Arab disturbs it not; why, exclaims Mr. Sivewright, should not Africa present a similar spectacle? And certainly, if Africa threatened the explorer with nothing worse than wigwams and ridiculous Arabs, our Colonial friends might be left to follow their own bent. Their estimate, also, of difficulties more within their own experience is highly characteristic, but to the English mind is not reassuring. They dismiss the African elephants and the monkeys with an airy contemptuousness which we who have been to the Zoological Gardens cannot pretend to share. The former have, so it is contended, been "magnified"—an incredible statement when the biggest beast extant is in question; and as to our mischievous forefathers, the superior cunning developed in man during a prolonged absence from his ancestral home is to be brought into play—there is to be only one wire, so that the monkey's propensity for making "contact" will be utterly floored. This is hard upon the "lower classes," but Mr. Sivewright is equally unfair and tricky towards the middle class, or transitional apes. He advocates a steel wire coated with copper. The unsophisticated Native will thus only get *a plated article* should he, as no doubt he will, take to cutting the wire for plunder or adornment. Unfriendly savages may be subsidised—the bullets are not mentioned,—and malarious wayroads can be kept in order by acclimatised niggers. All this is very refreshing, and we feel a sort of pride in a countryman who talks in that fashion—one who won't believe in the impossible, and who has stuff in him to accomplish anything short of that. It augurs well for the future of an overland line, and we heartily wish it success *in its due time*. But it should grow with the growing need for it. In the course of years—perhaps not very many—the North-Eastern shores of that unexplored Continent may be reached by telegraph from its Southernmost extremity, stage by stage, as commerce or conquest may carry it. But the immediate necessity is for communication with the mother country, with the other colonies, and with India, and this can only be had by way of the sea. The Society of Telegraph Engineers will, therefore, not be sorry that our Government has rejected a project fanciful, premature, and hazardous, for one that has at least swiftness and solid experience to recommend it.

CORRESPONDENCE.

CURRENT INDUCTION ON OVERHEAD WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been drawn to a telegram* from Mr. Edison contained in the last number of the *Engineer* relative to my Paper On Induction lately read before the Society of Telegraph Engineers.

The object of that Paper was, as there stated, "not to bring forward new instruments, but to discuss the question generally," and the results of my personal researches were there stated, not with a view of taking out patents myself, or bringing out patents of others. The discussion which was invited, and which will take place next week, amply sufficed for each patentee to bring forth his own solution of the difficulty.

Still, as far as laid in my power I was anxious to give credit where due. Thus, I learned, just before reading of Paper, that Mr. David Brooks, of Philadelphia, had already proposed the use of double twisted wires, and I at once gave him credit for the idea. I learned immediately after the lecture that Mr. Charles H. Wilson, of Chicago, had very beautifully resolved the difficulty as regards two wires by the use of coils and counter currents. This name was at once inserted in the printed report of the society.

I learn now from Mr. Edison's telegram that he also, as well as Mr. Wilson, used induction coils and counter currents, and that his claim would be found in patent No. 2,909, 1877. Of this I was unaware, as it was not patented in England under the head of "Induction," but under the title of "Telephone, or Acoustic Instruments." Still, if I had been aware of this claim in his telephone patent, I should have given him full credit, and cited the date of his patent.

If the question was simply his claim to his patent of 1877, I should at once freely and very willingly grant it, although I might have to criticise its value even for the compensation of a single line, as proposed in his patent.

But Mr. Edison leaves it to be understood that his patent is exactly the same thing as an instrument I showed (amongst many others), and that this instrument proposes the end by the same means as his own.

If Mr. Edison restricts his claim to the compensation of one line, then I freely accord it; but if he claims to have balanced all the lines on same poles as I proposed to do, I must beg to differ with him, and show the essential difference.

In describing this instrument in my Paper, I first described the lines with coils at relative distances, and showed how this would just double the induction, and do more harm than good. Now, this described exactly the theoretical conditions as shown in Edison's patent. But after showing what *would not do*, I demonstrated how, by fulfilling certain conditions (not one of which is mentioned in Edison's patent), a perfect induction balance could be obtained for all lines.

These conditions are too technical to fully describe here, but they may be summarised thus:—

1. Coils must be reversed at instant of putting on battery or its equivalent.
2. Coils must all have a certain definite length of wire in exact proportion to that of line used upon.
3. Battery power must also be proportionate to length, so as to have equal force on each line.

There are many minor details, such as provision for extra currents, static charge, &c. The main difference, however, between mine and Mr. Edison's is (leaving aside question of practical value and utility) that, as a simple laboratory experiment, Edison's arrangement as described in English and American patent, will compensate for a single line, but not for the rest of the many adjacent wires.

Mr. Charles H. Wilson's very beautiful and superior arrangement will perfectly compensate for two lines.

The arrangement I proposed compensates for all lines, each adjacent wire being perfectly free from induction.

Hoping that you may be able to find space for these remarks in your valuable journal—Yours, &c., H. E. HUGHES.

London, March 31st, 1879.

[The telegram referred to is as follows:—"Mr. Edison's Inventions: Just before going to press we received the following Atlantic cable message from Mr. Edison, at Menlo Park. Further reference to it will be made in our next:—'See my telephone Patent [of] July [last], figure twenty-eight anticipating Hughes' Induction Balance published [in] *Engineering*. [The] American patent [is] fuller; has identical [ly the same] devices as Hughes's.' The words in brackets we have supplied, in order to make the telegram clear."—ED. E.]

AN INQUIRY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would the following arrangement act as a relay to reinforce the volume of sound in a receiving telephone?

The current from the sending telephone to pass through a *fixed* coil at the receiving station; inside the fixed coil a core of soft iron, moving freely inside the coil, and placed vertically, the upper portion only of the core being inside the coil, and the weight of the iron core supported on a button of charcoal (which is specially manufactured), whose electrical conductivity would alter with variation in pressure. A battery circuit completed through the receiving telephone and the button of charcoal, the original telephonic circuit completed through the fixed coil. The original telephonic currents would suck up or let down the weight of the iron core on the charcoal button, and so alter the resistance of the circuit in which the receiving telephone is.

Head-quarters Camp, Kandahar, Afghanistan, R. E.
Feb. 11, 1879.

THE "QUESTION FOR STUDENTS."

TO THE EDITOR OF THE ELECTRICIAN.

In the experiment of "E. A. W.," the magnetic needle, so far as I can make out from his letter, simply moves in accordance with the well-known law of Ampère, viz., that, if we suppose the current to pass from our heels to our head, then, when we are looking towards the needle, its north pole will move towards our left.—Yours, &c., A STUDENT.

April 3, 1879.

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A NEW THEORY OF TERRESTRIAL MAGNETISM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad to see that Dr. Muirhead has questioned the report in *Engineering* of Professors Ayrton and Perry's Paper read at the Physical Society on the 15th inst., on "A New Theory of Terrestrial Magnetism." I heard that Paper read with great interest and much satisfaction. I quite agree with Dr. Muirhead. To my mind it is the only plausible theory that has yet been proposed to account for terrestrial magnetism, and it supplies a link which was wanting to comprehend that mysterious phenomena called "earth currents." When the Paper is published, it will certainly receive what it deserves, the most careful consideration of all electricians. W. H. PREECE.

March 31, 1879.

TELEGRAPHY; WHAT IT IS, WHAT IT HAS DONE, AND IS DOING.

PART II.

BY SIR J. ANDERSON.

[The following lecture (continued from page 225) was delivered at the Working Men's College on March 6. Mr. J. Pender, M.P., presided, and introduced the lecturer with a short but eminently practical speech. The lecture, delivered, as it was, to men presumably ignorant of electrical science, is, so far as the scientific portion is concerned, quite elementary.—Ed. *E.*]

In this second part of my Paper, "What Telegraphy has done and is doing; or, the result of the practical application of the science to every day life," I believe I shall be able to demonstrate that telegraphy has now become one of the most important subjects which political economists and statesmen—especially the rulers of the British Empire—have to deal with.

In the last twelve years telegraphy has changed the commerce of the world to an extent little dreamt of. This change, I venture to say, is only beginning to be faintly appreciated and understood.

The only writer I have yet known who has concentrated his thoughts upon this subject is the City Editor of *The Times* in his recent book, "A New Departure in the Domain of Political Economy," and some of my illustrations will be from that work. Thousands are using this agent of change without caring to pause and consider the new power which science has developed, and thousands find themselves baffled in the race of competition without recognising the power which is placing younger people, without their experience, and without their credit or knowledge of the old ways of commerce, over their heads. Five new commercial factors may be considered as established:—

1. Telegraphy is bringing the consumer face to face with the producer. 2. The middle men, or commission agents, are going out of the field. 3. The "foreign trade," in the condensed language of Mr. Crump, "*is becoming only an extended home trade.*" 4. "Orders, if sent in writing, are subject to modification by telegram." 5. Large stocks of anything are no longer necessary. You can order what you require to arrive just when you want it. For example, suppose an enterprising trader were now following the fortunes of our armies in Afghanistan, and saw that, if he had 1,000 pieces of Manchester goods arriving every month for six months, and beginning, say, by the first of May, he could telegraph to Bombay and arrange the price, and refer the merchant to his banker to satisfy himself as to his credit. The merchant would telegraph to Manchester and ascertain their price. The Manchester manufacturer could secure his cotton being replaced at a known price by telegraphing to New Orleans or any other cotton-growing district in the world, and in forty-eight hours the trader in Afghanistan would know that the whole transaction was completed, and a portion of the goods could be on the way in ten days, and, by way of the Suez Canal, would be in Bombay within six weeks from the date of giving the order, whether it was ten pieces or ten thousand.

This illustrates also the measure in which risk and speculation are diminished by telegraphy. The effect, of course, is to cut down profits, but it multiplies transactions enormously, and it prevents wide fluctuations.

I will illustrate this a little further. In former days—say fifteen years ago—merchants in grain would and could profitably speculate by buying up large quantities of grain, relying upon the effect of so doing to raise the price, because there was every appearance of a bad harvest in this country or on the Continent. And they would have time, in those ancient days of fifteen years ago, to produce the effect of raising the price of bread, oats, hay, &c., and make their profit before steamers brought the news from America, and all other grain-producing districts where there might be good harvests. Now that condition of affairs is impossible. Every morning the newspaper tells every man who cares to know the condition or change, if any, of every crop of every kind in the world.

It is, therefore, no longer of the slightest use—at least, it is daringly dangerous—to buy anything in the hope that you know more about it than others in the same business who want either to sell or buy. All the information is published morning, noon, and night, and can be bought for a few pence. It follows, then, that the days are altogether gone in which we can have famine prices for any of the staples of life in most civilised countries, and for more than one or two reasons.

First, every country can ascertain at about what price they can sell to some other country anything they can produce. This, for example, has induced India, America, California, and Australia to extend the growth of grain, which was absolutely not worth considering in some of these countries twenty years ago, until we could now do without Russia, upon whom we were formerly very dependent. And it has brought into use machinery for reaping, thrashing, and shipping. Canals, railways, and steamships have been multiplied for transporting, and this cheapening of the means of getting it in a state ready for market, and getting it to a market, has so developed as to induce the farmers to extend their operations—so much so, that districts as large as all the grain-producing area in this country have been brought into cultivation for the growth of grain in America in last year alone, and the grain grown in India has, in a few years, increased 600 per cent.

Second. The fact that every man in every country knows what he can sell, for about what price and within what time, is setting an ever-increasing number of commercial minds throughout the world to extend their operations, and you now see scores of articles of food being sold in costermongers' stalls and in the humblest retail shops as well as in the largest marts, which were unknown to our fathers and mothers. Most of them were either too expensive or too perishable to transport, but now steamers touch at every port, and on their arrival, with a few hours' notice, pineapples, bananas, oranges, oysters, crabs, fish, potatoes, cattle, and anything that man can eat may be bought and sold by telegraph; so that many districts—for example, around the coast of France and Bay of Biscay, and such islands as Malta—which, ten years ago, were very poor, can now produce something which will sell, and with the money they receive they are in a position to buy goods in exchange, and thus we have two results, viz., such a number of articles of food for man and beast available in response to a telegram that famine prices are no longer possible. "If one article fails partially, we can make shift with others," and we know exactly where they are and the day we can get them. And we have, secondly, such a multiplication of large and small commercial transactions that the telegraph, with the aid of steamships, has virtually opened up a vast, new, and invaluable field to the industries of the nations.

Any man with money can buy from the producer, at first cost, exactly what he wants, and get it at the time he wants it, and I suspect this has something to do with the success of co-operative stores. They have capital, and their subscribers are so many customers, on whom they can rely for the consumption of certain articles. They, therefore, soon learn to know how much of any perishable article they are likely to sell within a given time, and they can secure it direct from the producer, so as to have it always fresh and at first cost. I do not say it is exactly as I put it, or that more cannot be said for and against co-operative stores; but it must be so to a considerable degree, and I think the same general principles will be found influencing the labour market. If a strike should stop the production of any one or half a dozen articles in this country, they can be got elsewhere in a comparatively short time. Of course both employers and employed who are engaged in the trade dispute will temporarily suffer, but the consumers, who always constitute the great bulk of any community, do not suffer nowadays as they used to do. They can do without some special articles, and put up with something else until the dispute is over. Even labour can be shifted by steamer or rail in response to a telegram, and labour can be introduced into any one country from any other in a very few weeks or months. I believe this, more than anything else, perhaps, will make strikes less numerous, as they are already of less consequence, excepting to those who resort to them.

The long and the short of it is, then, that we can talk to, bargain with, buy or sell, within a few hours, often minutes, at any part of the world; and I think I have said enough to prove that every man can buy or sell goods or labour in any market of the world which seems most advantageous to him, with a reasonable amount of thought and consideration of the telegrams and articles published in the daily papers.

The class of merchants which, until recently, were a great feature of this country—I mean commission merchants and middle men—are rapidly dying out. From the tables in Mr.

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Crump's book to which I have referred I note these merchants have been leaving the business at the rate of about 200 each year for the last ten years in this country.

Another important change has occurred, and I do not yet know how to estimate its importance. Fifteen years ago the amount of grain, silk, and indigo, and many other articles imported into this country to be warehoused and transhipped to some other country, was three times greater than is now received, thus giving employment to a great amount of labour, filling our docks with shipping and our warehouses with goods. At present these goods are largely sent from the port where they are loaded direct to the destination where they are wanted for consumption. Or the ship is ordered to call at some port, such as Malta, Gibraltar, Falmouth, or Queenstown, where a telegram is received ordering her to her destination. Thus the merchant who first purchased the cargo has had time to re-sell it, or, perhaps, ascertain a more likely market for securing a profit, or, it may be, avoiding a loss. While the effect of this may be to alter the value of dock and warehouse property until some other change takes its place, the cost of warehousing and transhipping is saved, and the consumer gets the goods so much cheaper. Only three or four years ago it was and to some extent still is the practice for bankers and merchants to put money into the bank abroad and remit home by post a bill or piece of paper representing the amount. This, too, is changing every day. A merchant now puts his money into the bank, say in India, China, or Australia, and the bank telegraphs to England that it is done and the same day the house in England can use the money. As another example, a young friend of my own arrived in California from Australia, and telegraphed at 11 a.m. to London for money; by four o'clock the same day he had the money at his disposal in California. This facility of using money at all the extremities of the earth means that less capital is now required to conduct the same amount of trade which existed ten years ago. As a matter of fact, one sixth of the capital is sufficient to do the same amount of business. And as the population of the world is increasing—in America the population doubles in about thirty-five years, in this country in about sixty years, while production of gold does not progress in anything like the same proportion—this means of economising what we have got is all important. In fact, but for telegraphy, with an increasing population, you would have famines, and in the wake of famines, as usual, pestilences or epidemics. Whereas, with all the markets of the world open and accessible every hour, you have all the civilised communities on the face of the planet opening up roads, cultivating districts hitherto unknown, and creating, as Mr. Crump says, an extended home trade for the mutual benefit of all nations.

I have now to illustrate the methods which merchants have arrived at with the object of saving as much as possible in their telegrams. The practice nowadays is to charge so much for each word telegraphed. This practice I anticipate in about another year will become universal. Now any merchant, say in London, having a correspondent or house in India, can and does arrange a code, that is a whole book of words, so that each word means some separate transaction, or as large a part as possible of such transaction.

Diagrams 3 and 4 will illustrate what I mean, and thus it is coming about, one way or another, that the commercial world is coming into closer and closer relationship. A telegraphic language composed of several languages is coming into existence. New markets and new areas of production are increasing. Labour can shift itself about over the earth. The old ways of trade are going or gone, and we are all gradually settling down to a new order of things without any violent wrench to the community as a whole, but with ruinous effects to those firms which dealt with large credit. Now the small capitalist can deal to the extent of his means direct with any market as certainly as the greatest merchant prince, and this is what is developing—instead of a few large mercantile firms controlling any trade, there are numerous small ones springing up and carrying on business at the smallest possible profit. The profits are smaller, but the risks are reduced, and the number of transactions enormously increased, all to the benefit of the largest number, but, as many of us know, to the wreck of many once flourishing mercantile firms and the ruin of opulent homes.

One other point, and my story is told. It has been a good deal advocated lately that a telegraph through Africa would have a civilising influence; to my mind, this will not bear reflection. The telegraph is essentially a commercial agency—only the few comparatively well-off people can use it for affairs of social urgency; very few use it at all, unless it be to save money, or make money, or economise time, or, it may be, save life. But in such a continent as Africa, where there are no roads, there can be nothing called commerce worth telegraphing about, when the goods cannot be transported even if they existed, and it cannot be said that either time or even life has any value worthy of a telegram in such a country. The only great transporting highway which Africa possesses is the ocean round her coasts, and wherever there is a port to call at, there is the first point to place the civilising lever of trade. Whatever they have to sell will first seek the highway for transporting it, and the spot where merchants reside and ships call to exchange goods for their produce must be that point. If these ports are connected by telegraph, ships will more frequently call at them; first they can learn what quantity of cargo can be had there, and what can be obtained at any other port, and secondly, they can also consult with their owners, who have had the opportunity of considering the relative value of all the markets in the seas where their ships are trading. The effect of this is to increase ports of call, to promote commerce where it never existed before, and, as a natural consequence, to cause civilisation to spread from the seaboard towards the interior. In this sense only can the telegraph be called a civilising agent.

I shall not dwell upon telegraphy as a political weapon. A great deal could be said about it. It unites our empire so that the most remote extremities can be controlled from London. Troops can be moved from one point to another, peace or war can be declared, but it is just as well calculated to make war more terrible and sudden as it is to make peace more certain. Electricity can be used to fire torpedoes and mines, marshal armies, concentrate fleets, and it may be that such necessities will never die away. I prefer to look upon its humane aspect, and I have only one other general statement to make, which, if I did not wish to avoid any pretence to prophesying, I might term "what telegraphy will do." My opinion is that the rolling out of this electric cord all round the world, connecting all the islands, and all the continents across the broadest oceans is creating, silently and imperceptably, but surely and at a progressive rate, an international commerce greater than has ever been dreamt of in the history of the world, and at this moment not half understood by either merchants or statesmen.

Let us hope that when all nations find it to their own interest not to quarrel with any other, lest they destroy a good customer for their goods, or a prolific contributor to their own wants, they will be slower to engage in war, and more eager to combine to open up the waste places and dark continents of the earth to the present and future advantage, moral and material, of all mankind.

ELECTRO-METALLURGY: HOW TO MAKE A BEGINNING.

Some simple experiment—and this applies particularly to experiments in electro-metallurgy—has very frequently given birth to a taste for science, and has been the starting point of a more or less useful career in connection with its applications; and some paragraph, perhaps in a popular journal, which has accidentally been suited to the requirements of a youthful reader has often led to this experiment. We say "accidentally" because writers on science, even when this is to be "popularised," very seldom understand or heed the requirements of beginners; and, indeed, to write for them is an art which has not often been successfully cultivated. So true is this that we attempt the task with some diffidence, and experimentally. We shall be quite satisfied if we succeed in inducing some of our younger readers to devote a little of their leisure time to easier experiments, which, we feel assured, will not be altogether unprofitable.

1. *The Battery.*—How about a battery? will probably be the beginner's first question; and the answer to it is often his first difficulty. Now we have to tell him that there need be no difficulty about this matter. The mistake is generally in using too powerful, rather than too weak a battery. If he can get a strip of zinc and one of copper, he can have the battery best suited to his requirements at starting. The zinc is the *positive* and the copper the *negative element*. A piece of bell-wire—say eight or ten inches in length—will do very well for the negative. Let him get some fine wire—copper is best; but *any* fine wire will do, for the terminals; a piece of this wire, one foot or more in length, is to be attached to each element in any manner that will secure a good metallic contact, for instance, by tightly twisting the brightened end of the wire round the brightened ends of each element. Then the free end of the wire attached to the copper strip or wire will be the positive *pole*; and the end of the wire attached to the strip of zinc will be the negative pole. And any piece of copper (or other conductor) attached to the positive pole, and immersed in the depositing solution, will be the positive electrode or *anode*; whilst any conductor similarly connected to the negative pole will be the negative electrode or *cathode*. A piece of *magnesium* wire, or a flat band of this metal, costing a few pence, constitutes

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an excellent positive element, and may often be obtained by the experimentalist quite as readily as a strip of zinc. In London, magnesium may be purchased at the toy-shops as well as at the opticians', being employed for the production of the magnesium light by burning the wire or band.

Next, a vessel will be required to contain the battery elements and the "exciting fluid" which is to act chemically upon, or to dissolve, the metal constituting the positive element. For this, a common tumbler will do very well, being sufficiently tall to allow of fluid being added or removed, so as to regulate the action of the battery. The negative element may of course be bent, or twisted in spiral form, in order to secure the immersion of a sufficient extent of surface. Both elements, or the wires attached to them, may be bent so as to suspend the elements from the edge of the containing vessel; but a neater plan is to attach them to a piece of wood made to fit across the mouth of the vessel. The beginner should particularly note that the elements must *never be allowed to touch each other*. If they should come into contact, either within or outside of the exciting fluid, a *local circuit* is formed—from zinc to copper through the fluid, and from copper to zinc through the contact; whereas the object is to form a circuit from zinc to copper through the fluid, and from copper to zinc *through the anode and cathode* in the depositing solution. For the same reason it is essential that the connecting wires should not touch each other; and, to avoid any danger of their doing so, it is advisable that they should be covered with cotton, silk, or other bad conductor.

Next we have to consider the "exciting fluid" or *electrolyte* for the battery cell. An electrolyte is a compound, necessarily a fluid, which conducts electricity only by itself becoming decomposed. Dilute sulphuric acid—one of acid to ten or twelve of of water—is a very powerful exciting fluid (that is to say, a very good conductor for an electrolyte), and is that which is most generally employed with "single-fluid" batteries. We have, however, known several instances in which the young experimenter has been forbidden the use of the mineral acids (sulphuric, hydrochloric and nitric), and not without some reason, based upon the destructive effects of these acids upon linen, cotton, and other fabrics. We would especially warn the beginner against the insidious action, in this direction, of *dilute* sulphuric acid. Judged by its immediate effects, this appears to be a very innocent fluid; but the real acid in it, being non-volatile, is left behind when the aqueous portion has evaporated, and the corrosive effects of the concentrated acid then become manifested. It may, therefore, be of considerable importance to point out that common table vinegar (which contains acetic acid) may be used as an exciting fluid in lieu of dilute sulphuric acid. The vinegar, if strong, may be diluted with an equal volume of water. With this fluid there is no danger whatever of any destructive effects upon clothes and furniture. Again, if vinegar be used, there will be no need to *amalgamate* the zinc element—a process which is almost essential when dilute sulphuric acid is employed. The process of amalgamation consists in cleaning the zinc, immersing it in the dilute acid, and bringing into contact with each surface a small drop of mercury (quicksilver), which may be spread over the surface by means of a cork. The object of this process is to prevent the rapid action of the acid upon the zinc when the battery circuit is open—that is, to prevent what is termed *local action*, due to the impurities in the zinc forming with this metal minute voltaic couples. It is desirable, if possible, to dispense with the use of mercury in experiments performed at home, for this metal, if accidentally dropped about on the floor, may exert a prejudicial effect on health. It should be mentioned that, when vinegar is the exciting fluid, the elements should be somewhat larger than when dilute sulphuric acid is used. When magnesium is used as the positive element, the electrolyte may be a solution of common salt, more or less dilute according to the strength of the current required.

It may here be observed that all single-fluid batteries produce a greater effect when first they are circuited than after the circuit has been for some time closed. The reason of this is a fall in the *electromotive force* of the battery, which is due to an "electro-plating" of the negative element with condensed hydrogen, an effect which is generally referred to as the "polarisation" of the element in question. When the exciting fluid becomes saturated with dissolved zinc, this electro-plating with hydrogen gives place to an electro-plating of the negative element with *zinc*, which, of course, soon brings the action of the battery to a close. So long, however, as there is free sulphuric, or acetic, acid present in the exciting fluid, the electromotive force of one cell such as we have described will be sufficient to produce the electro-deposition of copper, from a solution of the sulphate of that metal, when both electrodes are of copper. The quantity of metal deposited will then mainly depend upon the size of the battery elements (or the extent of surface immersed) their proximity, the degree of concentration of the fluids, and the size of the electrodes. When the depositing solution contains a cyanide or ammonide of copper, at least two of these cells should be used, connected *in series*, that is to say zinc to copper, leaving a terminal zinc and a terminal copper with connecting wires for the attachment of the electrodes.

2. *Depositing Solutions for Copper.* (*a*) For depositing on copper, on carbon, on blackleaded surfaces, &c.—For these purposes the best solution we know of is that recommended by Mr. Sprague, viz.:—Saturated solution of sulphate of copper diluted with one-fourth its volume of water containing one-tenth by measure of sulphuric acid. A saturated solution is one that will dissolve no more of a given salt.

If it be required to dispense with the use of sulphuric acid, vinegar may be used instead; and we have obtained a good deposit from a saturated solution of sulphate of copper diluted with one-fourth its volume of a mixture of equal parts of household vinegar and water.

A first experiment should be tried (and several times repeated) with the above-mentioned cell, two small electrodes (anode and cathode) of copper, and a small quantity of either of these solutions, contained in a tumbler or other convenient vessel. Let the electro-deposition be continued for a day or two in each instance, and observe any differences in the quality of the deposited metal when the current is varied by augmenting the immersed surfaces of the battery elements, &c., as above mentioned.

(TO BE CONTINUED.)

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY (LIMITED).

The Forty-third Ordinary General Meeting of the shareholders of this Company was held on Wednesday, the 2nd of April, at the Cannon-street Terminus Hotel, under the presidency of Sir James Carmichael, Bart., the chairman of the Company.

The report stated that in the past half year there had been a falling off in the revenue as compared with the previous half year, which was due to the suspension of traffic between Otranto and Corfu for almost the entire period of the last quarter, in consequence of the cable being injured. They had been compelled to call on the Government for the full amount due under the guarantee.

The CHAIRMAN, in moving the adoption of the report, said: I have to express very great regret, both on my own account and that of my colleagues, that this meeting has been so long delayed. You are aware that it ought to have taken place about a month or six weeks ago. This delay, however, was unavoidable. It has occurred through an objection on the part of the Treasury to the form in which our accounts were sent in. We very properly, as we thought, charged the cost of our repairs, as usual, against the revenue, but the Government auditor, on the contrary, was of opinion that we should have taken the cost of these repairs out of our reserve fund. Well, we pointed out to the Treasury that that was a very unusual proceeding—that in all telegraph companies it was customary to charge the cost of the repairs of each half year against the revenue of that half year, and to keep the reserve fund untouched, except in the case of a partial or total renewal of cables, in which case the reserve fund became available. After considerable discussion, I am happy to say that the Treasury took our view of the matter, and eventually the accounts were passed by the Government auditor in the form in which they were at first presented. That leaves us in a position to recommend the usual dividend on the ordinary and preference stock, and to keep our reserve fund untouched for future occasions if necessary. Therefore, although the delay has been productive of some inconvenience to the shareholders, still it resulted in a favourable arrangement with the Government officials. With regard to these repairs, as stated in the report, the one respecting the repairs to the cable between Corfu and Otranto has been carried out successfully, and the cable is now in good working order. I regret to say, with regard to the Alga-Grande cable, one of the cables between Sicilly and Malta, we have been obliged for the present to abandon any further efforts to repair it, and I should hardly be justified in recommending a further expenditure on the cable. The cable was laid some twenty years ago, and at that time, as you are very likely aware, it was not the custom to give the wire coating of the cable any further protection. The cable laid since then, which has been down some ten years, has been covered with a composition commonly known by the name of Clark and Bright's patent, which preserves the iron from the action of the salt water. There is the second cable, now in working order, between Pozzallo and Malta; it is in excellent order, and capable of doing all the business that we have. At present, therefore, I should not advise further expenditure on the Alga-Grande cable. Hereafter, it may be a question of renewing it, but not just now. I don't know that I have anything further to say, except that I shall be happy to answer any question from any shareholder. I now move the adoption of the report and accounts

The Hon. ASHLEY PONSONBY formally seconded the motion.

Mr. ROBINSON said he would give the Chairman and the Directors, and their excellent Secretary, great credit for overcoming the difficulties they had had to contend with, as against the Treasury, in order to get the money for them to pay the dividends this half year. Both the Treasury and the Company viewed the question in the light most favourable to themselves; but no doubt justice had induced the Treasury to take the Company's view. That being so, he must say that he was very satisfied with the report presented to them; he considered it highly satisfactory, and hoped the shareholders generally would be of that opinion. With regard, however, to their tenure, within a very short period the ordinary dividend they now received must cease, because the Company, they saw,

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was earning not sufficient to pay the preference shareholders anything. It, therefore, behoved them as shareholders to ask the Board to take every step they could before the subsidy to the line expired to remedy the fatal position they would be in at the termination of the subsidy. They had connection, and, no doubt, some weight with the telegraph companies, and they should strive their utmost before it was too late to obtain some terms by which they could obtain much or little when the subsidy ceased. Every half year they met their property became less valuable unless something were done to redeem them from their unfortunate position. They had at present a certain amount of reserve, but the subsidy ceased in between three and four years. Their shares were worth 4, 6, or 8 years' purchase, and if that was offered to any company with the advantages they possessed in having a line in good order, and with a certain amount of reserve fund, he thought something might come of it. He considered that if they had an interview with some large company something might be done which might entirely obviate the possibility of their having no dividend.

Mr. VEARES and another shareholder considered that Mr. Robinson had taken a too gloomy view of the position of the Company, and that affairs with them were not so bad as he seemed to believe.

The CHAIRMAN, in reply, said they were all, he thought, of the same opinion, that if they could get any desirable amalgamation they would be only too glad, but he was sorry to say that hitherto they had not been successful. Their late chairman had a long correspondence and personal interviews with the chairman and directors of the Eastern Telegraph Company, but these efforts arrived at nothing, because the company would not make them any tangible offer. Last year there was a strong expression of opinion that they should make the attempt again; but it ended as before—they could obtain no definite offer. He thought the best plan was to make their property as valuable in itself as they possibly could. They were now doing their best. Their Corfu agent was at Rome, and they hoped to get some alteration in the tariff, which would improve their position.

Mr. CAMPBELL said the Eastern Company declined to purchase their undertaking on the only basis on which they could go—the market value. That company said they could not think of going on such a basis.

The CHAIRMAN: Besides that, this was not a cash payment, but in shares of the Eastern Company.

The report was then unanimously adopted, and the dividend on the special preference stock, less income tax, and a dividend at the rate of 3 per cent. per annum on the ordinary stock, tax free, were declared.

The CHAIRMAN, in reply to a vote of thanks, said that the directors would lose no opportunity of improving the position of the shareholders, and if they could they would be only too glad to be able to carry out some arrangement which would put them in a better position.

The proceedings then terminated.

INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).

The half-yearly general meeting of the shareholders of this Company was held on Monday, the 31st of March, at the Cannon-street Hotel, under the presidency of Colonel James Holland, the chairman.

The report of the directors stated that since the last general meeting the Indo-European Government Telegraph Department had become parties to the joint-purse arrangement theretofore subsisting between this Company and the Eastern Telegraph Company. This arrangement continued to work satisfactorily, and with advantage to the public. The Company's revenue from all sources for the year 1878 was £85,234, and the expenses £45,539. After charging £7,005 percentage upon profits, payable to Messrs. Siemens, under the maintenance contract, taking credit for the balance brought over from last year, £2,830, and deducting income-tax, there remained the sum of £35,046, from which £10,625 already paid had to be deducted, leaving a net balance of £24,421 available. They proposed to declare a further dividend of 17s. 6d. per share, making, with the interim dividend already paid, six per cent. for the year 1878 tax free. This would leave a balance of £9,546. Seeing that the item of £5.194 paid on account of the liquidation of the Persian debt, standing in the suspense account as payable to Messrs. Siemens, when recovered by deduction from the annual tribute payable to the Persian Government would, had the original method of liquidation remained without alteration, be now in course of recovery to the amount of £2,606, and that Messrs. Siemens received no interest on this sum, the Board had decided to pay them the above amount. Out of the remainder £6,000 was proposed to be restored to the reserve fund, and the balance of £939 to be carried to the credit of the current year. The directors last year succeeded in obtaining the consent of the British Postal Department, and of the German and Russian Governments, to the establishment by the Indo-European line of a service with Turkey *viâ* the Odessa and Constantinople cable, which had added to the Company's revenue. Messages are exchanged with Constantinople by this route on the average in about one hour and a half.

The CHAIRMAN, in moving the adoption of the report and accounts, said it was no doubt a matter of satisfaction to the shareholders, as it was to the directors, that they are able to present a report which was so much more satjsfactory than that of 1877. That year unfortunately was marked for them by the Russo-Turkish war, owing to which between sixty and seventy miles of their line of communication was destroyed, and so remained for several months. They had, however, formed a reserve fund, and that, combined with the energy of the Board, and very greatly with the energy of the contractors, Messrs. Siemens, enabled them to establish a line through the Caucasus, and the effects of the disaster were not such as to deprive the shareholders of a dividend. Although the accounts of the past year might have shown a better result, they showed that the amount received as gross revenue was larger than on any previous occasion, being over £90,000. There had been continued depression in trade, and though there were some improving prospects the depression still continued, and so long as it existed they could not expect the average amount of business with a derangement of mercantile transactions in India and other places. The total receipts of the past year, however, had been satisfactory, and there had been a steady increase, the dividend having always been progressive, with the exception of 1877. They recommended a dividend for the past year of 6 per cent., adding £6.000 to the reserve, thus replacing the fund in its former position. Excepting a few amounts due to them from Government every shilling of the debtor and creditor accounts had been cleared off. The gross expenses for the past year were stated at £45,539, but a sum of £589 had been expended in the purchase of the freehold of a station, and after deducting some further extraordinary amounts the expenses were actually £500 or £600 less than those of 1877. With regard to the reserve fund, he presumed that there was no one who would question the policy of having a good reserve. The reserve fund had been their salvation in the past, and might be again, and therefore it would require no eloquence on his part to impress upon the shareholders the necessity of adding to that fund. Their policy had been to pay everything out of revenue, keeping the capital at a *minimum*. As to their claim against the Russian Government for the destruction of the wire, he had hoped to be able to announce that it had been met by the Government, but although they had met with no rebuff, the claim still remained unsettled. Government powers were slow in motion when the payment of money was concerned, but the directors would not relax their efforts, although they must not be impatient. Such a claim as theirs on the Russian Government was never refused by any civilized Government, and he trusted to hear that a considerable amount had been paid to their account, and that before long the whole claim would be satisfied. The system adopted some years ago by which representatives of the Press at distant stations were enabled to transmit messages at quarter rates when the wires were not occupied for the ordinary business of the company had worked well to the advantage of the Press and the general public. They had made strenuous efforts, in conjunction with the Eastern and the Eastern Extension Companies, to extend this privilege still further; but he regretted to say that they had not hitherto met with much success, foreign Governments, for various reasons, finding it difficult to aid the movement. The directors would, however, still continue their exertions to carry out this object. With regard to the International Telegraph Conference, which was held every three years in one of the principal cities of Europe, it would this year take place in London, and the Postmaster-General had invited the Company and the representatives of other companies to attend it. The directors had accepted the invitation. They should strive to repay the warm hospitalities they had received abroad—whether at Vienna, St. Petersburg, or Berne, and he hoped that our Government would not be behindhand in repaying the hospitalities of foreign Governments to the British representatives at these conferences. He concluded by moving the resolution.

Mr. W. H. BARLOW, a director, seconded the motion, which was at once unanimously adopted. The dividend as recommended was then declared, and subsequently resolutions were passed re-electing the retiring directors —Mr. J. H. Gossler, of Hamburg; Colonel Holland, and Mr. H. H. Meier, of Bremen; and the retiring auditors, Messrs. C. F. Kemp, Ford, and Co.

The meeting closed with votes of thanks to the Chairman, Directors, and the Manager and Secretary.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).

The half-yearly general meeting of the shareholders in this Company was held on Monday, the 31st of March, at the offices, 106, Cannon-street.

Mr. NEIL BANNATYNE, the chairman, presided, and in moving the adoption of the report, the salient features of which have already been published in *The Electrician*, said he had no doubt the shareholders had observed that the feature of the accounts was an increase in the working expenses for the past half year, but he was glad to be able to state that the increase arose from exceptional causes, some of which would not occur again, and others not for some years. The details showed that the normal working expenses had not increased, and that the Company could carry on a large increase of traffic with the same expenses. The traffic did not come up to his expectations, but it had enabled the directors to increase the reserve fund to £1,700, and to carry forward a small balance after paying the preference dividend. They had not lost any of their customers, but they had had fewer telegrams; the area, however, from which they drew their customers was as great as ever. When a revival of business occurred he had no doubt the position of the Company would improve, but there was no immediate prospect of an improvement in the depression of trade. He concluded by moving the adoption of the report.

The motion having been seconded,

Mr. HOOPER said he had scanned the report for the last three or four years, and had been struck with its uniformity. As usual, it contained good news for the preference shareholders, but the ordinary shareholders had been left unsatisfied. Some three or four years ago he invested between £3,000 and £4,000 in ordinary shares, and he also invested £500 in preference shares. He could not understand the wisdom of loading this little Company with £60,000 worth of preference shares. If the directors had kept to the original property for the last three or four years, the ordinary shareholders might have had a reasonable dividend of, say, 4 to 4½ per cent. He could not but think it was the duty of the Board to see if something could not be done for the ordinary shareholders, who subscribed £116.000 and never got anything. Did the Board see any reasonable prospect of any improvement? From advertisements he had seen in the newspapers, it struck him that other companies were going to thrust a spear into their side, and, with reference to announcements by these companies, he would like to know the time occupied by this Company in transmitting a message between London and Madrid.

In reply to Mr. Hooper and to other questions and observations, the CHAIRMAN said the directors were themselves suffering. One reason why the directors thought it advisable to purchase the Bilbao and Marseilles Company was the unremunerative position of their Company. The directors could not foresee that the traffic would fall off. They offered the Ten per Cent. Preference Shares to the ordinary shareholders, and if any man who had 100 ordinary shares had taken 100 preference shares, he would have been receiving 5 per cent. to that day. The receipts on the Bilbao and Marseilles line had improved within the last eighteen months, but they were still a long way off the original receipts. The fact was that when the earliest insurrection was put down the land lines came into competition and had taken away their traffic. As regarded the future, the directors would be happy to adopt any suggestion that could be legally carried out,

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but the only way in which they could see a prospect of a dividend for the ordinary shareholders was an increase in the traffic. As to the expenditure, he had said that they would bring it under £4,000 a year, and they had done so; but they could not help a few exceptional expenses. With regard to the future, the first object of the directors was to have something in hand, so that they might repair the cable and put it in efficient working condition. They must have a reserve fund, as they did not want to call on the shareholders for another £1. When that had reached a reasonable amount, say £3,000, there would then be something for the ordinary shareholders. With reference to the time occupied by the Company between London and Madrid, the average had been seventeen minutes. He did not say they could always do it in that time, but he thought that was some evidence of the ability of the Company to hold its own.

In the course of some further discussion it was suggested that the preference shareholders accept a lower percentage on their shares in order to enable the ordinary shareholders to get a small dividend, Mr. Hooper suggesting that the Board should make a suggestion to that effect.

The CHAIRMAN, however, said it was not the duty of the Board to move in the matter. So far as he was personally concerned, he was quite willing to agree to the proposition, but it was not his duty to suggest it. He did not, however, take such a desponding view of the position of the Company as some. On the contrary, he thought that they might reasonably expect that the Company would be able, before many years were over, to pay on the ordinary shares.

Ultimately the report was carried unanimously, and the Chairman and Mr. Scott were re-elected directors of the Company, Mr. James Cowan, the auditor, being re-appointed auditor.

The meeting concluded with a vote of thanks to the Chairman.

RECENT PATENTS.

2456. TELEPHONY, *H. J. Haddan.—Dated 20th June*, 1878.—(*A communication.*)—(*Not proceeded with.*) 2*d.*

A "condenser" is used in combination with a telephone, so as to enable the latter to be connected with the wire of a galvanic circuit without interfering with the action of such circuit. Two or more wires of a telegraph line running in the same direction are connected and used as a conductor, thus greatly reducing the resistance of the line. The wire of a telephone circuit is "grounded" at one or more intermediate points, and a "condenser" is inserted in the ground wires, so as to diminish the effect of foreign induced currents. Two or more independent galvanic circuits are connected by means of a "condenser" to form a telephonic circuit without interfering with the galvanic circuits.

2457. TELEPHONES, &c., *J. L. Haddan.—Dated 20th June*, 1878.—(*A communication.*)—(*Not proceeded with.*) 2*d.*

This consists of a telephone and a signalling apparatus in one instrument, and is composed of one or more permanent magnets which are used in common for the purpose of magnetising the cores of the telephone electro-magnets used for the production of induced currents for signalling purposes.

2527. TELEPHONES, *C. H. Siemens.—Dated 25th June*, 1878.—(*A communication.*) 6*d.*

This consists, first, in constructing telephones with a casing or cover enclosing the iron diaphragm, and having a hole serving both for the transmission of pulsations when speaking and for the reception of a sounding instrument for signalling, side passages being formed in the said cover for the escape of air pulses. Secondly, the combination with a telephone of a sounding instrument arranged to fit into the hole of the cover thereof, so that by sounding such instrument corresponding pulsations are imparted to the diaphragm. Thirdly, the use of a loose hammer or ball carried by the sounding instrument, and arranged so that when this is fitted to the telephone the hammer will rest upon the diaphragm.

2554. TELEGRAPHIC APPARATUS, *C. A. Bramäo.—Dated 26th June*, 1878. 8*d.*

This consists, first, in the employment of a circular armature composed of two half circles, each of these presenting two poles of the same name at their extremities. Secondly, a particular arrangement of the poles of the magnet, as also the electro-magnet. Thirdly, the employment of a set of levers capable of maintaining the armature in a position of repose by means of two springs, so that it may oscilate in two opposite directions. Fourthly, the employment of a commutator permitting the employment of the apparatus with two batteries instead of one; or, in the latter case, permitting the connection of one of the poles of the battery with earth to be automatically established when the emission of current is effected with the other pole on the line. Fifthly, the combination and establishment of 370 signals or more, by means of which one may transmit or deciper without having recourse to a code of signals, it being sufficient to know by heart those constituting the ordinary alphabet. Sixthly, the combination of a vocubulary or phrase dictionary, each expression up to 105, 400 of which does not require more than two of the simplest signals or letters of the "Morse" alphabet.

2722. TREATMENT OF OLD OR DECOMPOSED CAOUTCHOUC, *L. Dauckwerth and R. D. Köhler.—Dated 8th July*, 1878. 4*d.*

Old or decomposed caoutchouc is submitted to dry distillation in a boiler or retort by fire heat combined with the action of superheated steam. By this means the volatile substances are distilled over from the caoutchouc, which, when condensed, form oils and a substance, when vulcanised possesses in a great degree the properties of natural caoutchouc.

3250. PRODUCING AND REGULATING ELECTRIC LIGHT, *H. Wilde.—Dated 17th August*, 1878. 6*d.*

Two carbon pencils are placed parallel to each other, and are fixed in separate holders. The holders are fixed to a base of wood or other non-conducting material, and are so constructed that the distance of the carbons from each other may be adjusted to any degree of closeness without the holders coming into metallic contact. The carbons are connected respectively with the polar terminals of an electro-magnetic machine producing alternating currents. When the light is required, the circuit is completed between the carbon points by a solid conducting substance, or by a paste composed of carbon, mixed with oil or gum. The strength of the current and the thickness of the carbons and their distance apart are so proportioned that the light is produced from the upper extremity of the carbons, which burn downwards with regularity until they are consumed.

3750. ELECTRICAL SIGNS FOR ADVERTISING, *J. L. Blackmer.—Dated 3rd September*, 1878.—(*Complete.*) 6*d.*

The sign board has openings made through the bodies of the letters thereon, and suspended in such openings are pendants of any desired form. The board is pivoted in a suitable frame, to which is connected an electro-magnet with a small battery, so as to communicate to the sign board a slight vibration, which will cause the pendants to vibrate, thereby reflecting the light in such a manner as to cause the sign to be observed at a long distance.

4278. APPARATUS FOR ELECTRIC LIGHTING, *E. J. C. Welch.—Dated 25th October*, 1878.—(*Complete.*) 6*d.*

Two series of contact pieces are employed, one fixed and the other movable, the pieces in each series being either insulated or not, and being so spaced with regard to each other, so that when one series is in motion the contact pieces therein may come into electrical contact with the pieces in the other series, either singly, successively, or in any order of combination that may be required. Thus any number of contacts may be made in one revolution of one of the series, according as the contact pieces are arranged in circles or in straight or curved lines.

TELEGRAPH SHARE LIST.

COMPANIES.	CLOSING PRICES APRIL 2.		BUSINESS DONE WEEK ENDING APRIL 2. Highest.	Lowest.
Anglo-American	57¼, ¾		58	57¼
Do. "B"	86½, 7		87	86½
Do. "A"	29, ½		29½	29
Brazilian ex div.	6 11-16, 13-16		6 15-16	6¾
Cuba	8, ¼		8½	8¼
Do. Ten per Cent. Preference	15, 16		—	—
Direct Spanish	1½, 2		—	—
Do. Ten per Cent. Preference	10½, 11		10¾	10½
Direct United States	11, ¼		11¼	11
Eastern	7 7-16, 9-16		7 9-16	7 7-16
Do. Six per Cent. Debenture	105, 8		106¼	106¼
Do. Five per Cent. do.	100, 2		—	—
Do. Six per Cent. Preference	11¼, ¾		11¾	11¼
Eastern Extension	7⅞, ¼		7 9-16	7⅞
Do. Six per Cent. Debenture	106, 9		108	106½
German Union	7½, 8½		—	—
Globe Telegraph and Trust	4 13-16, 15-16		4 15-16	4¾
Do. Six per Cent. Preference	10 9-16, 11-16		10½	10½
Great Northern	8½, ⅜		8 3-16	8¼
Indo-European	21, 2		—	—
Mediterranean Extension	2½, 3½		—	—
Do. Eight per Cent. Preference	9½, ¾		9¾	9¼
Reuter's	9½, 10½		—	—
Submarine	215, 25		223	220½
West India and Panama	1¼, ¾		1¾	1 11-16
Do. Six per Cent. Preference	8¾, ⅛		—	—
Western and Brazilian	3¾, 4		3¾	3¼
West. Union Seven per Cent. 1st Mort.	114, 18		—	—
Do. Six per Cent. Sterling	101, 3		101¾	101¾

TRAFFIC RECEIPTS FOR MARCH, 1879.

COMPANIES.	March 1879.	March 1878.	Increase.	Decrease
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,100 estd.	3,517	—	417
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Great Northern Telegraph Company	—	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

ELECTRICAL AND SCIENTIFIC APPARATUS for AMATEURS and the TRADE.—Microphones of every form from 1s. 6d.; new cheap Electric Lamps and Batteries; Automatic Switch Boards, Electric Bells, Fire and Thief Alarms; Induction Coils and Frictional Machines are specialities. Magnets, Covered Wires, Carbons, and all materials. Illustrated Catalogue, one stamp. Repairs and alterations. Apparatus made to sketch.—DALE and CRAMPTON, Manufacturing Electricians, 4, Little Britain, E.C.

J. M. THISTLETON & SON,
51, GREAT PORTLAND STREET,
Makers of Galvanic Apparatus, Coils, &c., for Lighting Gas Sun Burners, and of Electric Bells, Indicators, Fire Alarms, and Thief Detectors.
Induction Coils, Batteries, and every description of Electrical Apparatus repaired or made to order. Manufacturers of Flexible Silk Cord; Silk, Cotton, or India-rubber covered and other Insulated Wires. THE TRADE SUPPLIED.
Every description of Scientific Instrument repaired or made to order, Missing Parts supplied where required. Electro Gilding and Nickel Plating quickly and cheaply. All work done on the premises by competent workmen at moderate charges.

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NOTES.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).—The average time occupied in transmission to Madrid by the direct wire, *viâ* Bilbao, by all telegrams for Spain, Portugal, &c., during the week ending 29th March was twenty-nine minutes from any office in London, and forty-eight minutes from any other station in England, Scotland, or Ireland.

MILITARY TELEGRAPHS.—According to *The Times* correspondent, the telegraph to Candahar was, on March 30th, probably completed, never, it is hoped, to be withdrawn. There will, therefore, be a gap of only 600 miles, from Mashad to Candahar, in the overland wire from India to Europe by this route. To stop this gap will be an early task in the regeneration of Afghanistan.

AMPÈRES CYLINDER.—The first person to employ a horse-shoe magnet with this apparatus was William Sturgeon. An account of his apparatus appears in the *Phil. Mag.* for Sept. 1823, as follows:—"The apparatus consists of two sets of revolving cylinders, one suspended on each pole of a horse-shoe magnet. Upon the usual insertion of the diluted nitric acid, the two sets of cylinders simultaneously enter into rotations in a very interesting and striking manner."

THE WONDERFUL LAMP.—The *Daily News* of April 9th has a long article and a short leader on the Edison light. What a pity it is that the writer of the leader did not confer with some of the scientific men he tilts at, before giving his lucubration to the world. We do not deny Mr. Edison's energy, or the beauty of his lamp, or the amazement we labour under as discovery after discovery is hurled at us, but we do deny, till stronger proofs are forthcoming, that the electric light by incandescent metals is more economical than the arc.

TELEGRAPHIC CORRESPONDENCE WITH GERMANY.—A Parliamentary paper which has been issued contains the agreement between Great Britain and Belgium, signed at London December 31, 1878, and to take effect from January 1, 1879, for facilitating the application of a word tariff for telegraphic correspondence exchanged by way of Belgium between Great Britain and Germany. Under this agreement telegrams so transmitted "shall be subject to a transit charge of five centimes per word to be placed to the credit of the latter country."

THE TELEGRAPH TROOP FOR NATAL.—The transport Borussia, Capt. Williams (hired from the Mississipi and Dominion Steamship Company), which has been detained at Portsmouth by the breaking down of its steam windlass, sailed for Natal on the 4th April. She embarked at Portsmouth the right half of the C Company of Mounted Royal Engineers, consisting of Major A. C. Hamilton, Lieuts. J. C. Macgregor, J. Hare, H. B. Rich, and F. G. Bond, nine sergeants, 163 privates, 109 horses, and thirteen waggons. On arrival at the seat of war the Engineers will form the Land Transport and Telegraph Corps, and will be placed under the command of Major A. C. Hamilton.

THE ELECTRIC LIGHT PRODUCED BY THERMO-ELECTRICITY.—We understand that Mr. Latimer Clark has taken up the question of applying a thermo-electric battery for the production of light. Several months ago we announced that M. Faure, the manager at the cotton-powder factory at Faversham, was engaged upon the same problem; and we may now add that he has overcome several of the most serious difficulties in the way of bringing this application within the domain of practice, and that his skill and perseverance would seem likely to be fully rewarded by success. In Paris, also, this important question is receiving considerable attention, MM. Clamont and Denayrouse being engaged in experimental trials with the thermo-pile devised by the former electrician.

THE SOCIETY OF TELEGRAPH ENGINEERS.—The balance sheet of this society, just issued with the current number of its journal, is not a very gratifying document. The total amount of subscriptions received on account of the Conference reception fund is £57 8s., of which only £51 12s. 6d. is now available. This, considering the unexpectedly long period during which the society's appeal has been before its members, is a disappointing result. It is to be hoped that promises have been received to a much larger amount, or that a fresh effort will be made to provide more adequate means for welcoming the Conference, which is now fixed for June. The ridiculously small sum of £6 18s. received for catalogue's of Ronald's Library does not excite so much surprise, as the Society, to the best of our knowledge, has spent a great deal more time and money in asking for subscriptions than in acquainting their members with the accessibility of the library itself. The printing and stationery bill has accumulated till it amounts to £833, a figure not to be wondered at when the realisable value of the journals *in hand* is estimated at £563—an estimate, we should say, very greatly exaggerated.

SOLUTIONS FOR CHEMICAL PAPER.—The following are given in Prescott's "Electricity":—No. 1. Nitrate of ammonia, about 4lbs, ferri-cyan. potassium about 1oz., gum tragacanth 4oz., glycerine 4oz., water 1 gallon. No. 2. Nitrate ammonia 2lbs., muriate of ammonia 2lbs., ferri-cyan. potassium 1oz., water 1 gallon. No. 3. Iodide of potassium ½lb., bromide potassium ½lb., dextrine or starch 1oz., water distilled 1 gallon. No. 4. 150 parts crystallized nitrate of ammonium, 5 parts ferro-cyan. potassium and 100 parts water. No. 5. One part iodide of potassium and 20 parts starch paste in 40 parts water. No. 6. Add two parts nitric acid and two of ammonia to a solution of prussiate of potash in water, about 1½oz. to the gallon. No. 7. One part ferro-cyan. potassium saturated solution, 1 part nitrate of ammonium, one part of each solution to two parts of water. Of the above, No. 1 may be considered best for steady work on short circuits; being also of comparatively high resistance, it is least affected by leakages from other lines. No. 2 is much more sensitive, and can be made to record with the faintest trace of current, it is, therefore, well adapted for long circuits. No. 3 is highly sensitive, and capable of the most perfect and beautiful work at an extremely high rate of speed.

THE PROPOSED AFRICAN OVERLAND TELEGRAPH.—The report of the conference on this question, held in order to give some information to the Government, states that *three* overland routes have been suggested, called respectively the

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"West Central," the "East Central," and the "Coast" lines. It appeared preferable to recommend the East Central, for the following reasons:—(1). It follows the course of the Nile up to Lake Victoria, one-fourth the whole distance, and the Egyptian Government undertakes (according to Mr. Giegler) to erect it, and protect it up to Mtesa's territory. (2). It opens up the chain of lakes from the Nile to the Zambesi, on all three of which Europeans have established one or more settlements, which will by this means be brought into communication with Great Britain. On two of these lakes steamers have already been placed, thus they afford water communication for many hundred miles, and facilities for transporting and forming *depôts* of materials. (3). It is the most direct, shortest, and least expensive line to Pretoria, consistent with deviations which it has been judged advisable to adopt for the purpose of securing facilities of construction and the accession of future business, (4). It has, for the greater part, been traversed by one or more travellers, and it will doubtless be the route by which commerce and attendant civilisation will first penetrate the continent. The conference strongly advocated a land line, but in the light of recent events we might ask what guarantee have we to commence with that the Egyptian Government would erect and could protect a thousand miles of line.

Salts for Recording Signals.—The following salts, decomposed by the action of electricity, with the production of a recorded signal, were claimed by Professor Morse in the specification of his electro-chemical telegraph:—*Class A:* A class of salts that produce a coloured mark upon cloth, paper, thread, or other material under the action of electricity. 1st. Iodide of tin in solution; 2nd. Extract of nutgalls and sulphate of iron, in solution, making an ink which colours white cambric cloth of a uniform grey colour; 3rd. Acetate of lead and nitrate of potash in solution; 4th. Iodide of potassium in solution. Into either of these I dip a strip of cloth or thread, which is kept properly moistened. All these give a black mark upon the cloth, thread, or other material under the action of electricity.—*Class B:* A class of salts which colour the cloth, paper, &c., and are bleached by the action of electricity. 1st. Iodide of tin in solution. 2nd. Iodine dissolved in alcohol. Into either of these I dip a strip of cloth, paper, &c., and, if in solution second, I also dip them into a solution of sulphate of soda, the cloth or other material, in these cases, becomes of a purple colour more or less dark. The electricity in these cases, when a metallic point or type is pressed upon, or comes in contact with, the moist cloth or other material, bleaches it, and leaves the point or the type in white characters upon the material. —*Class C:* A class of salts that produce a mark upon metal, through the intervening cloth, or other material, and not upon the material under the action of electricity. First, sulphate of copper in solution; second, chloride of zinc diluted with water; third, sulphate of iron in solution. Into either of these solutions I dip the cloth, thread or other material, and if into the third, I afterwards dip it into muriate of lime in solution. The electricity in these cases causes a dark mark upon a bright metal plate beneath the moistened, but not on the material itself. Nitrate of lead, producing the brown peroxide at the anode, was used by the Chevalier Bonelli in his recording telegraph.

Telegraph Statistics of India for the Year 1876-7. —There were 39,700 miles of wire, and 17,840 miles of line belonging to the Indian Government Telegraph Department in India and Ceylon at the close of 1876-7, while the number of signal offices was 234. Every year has shown a great increase in the number of messages, which aggregated 1,166,833 in 1876-7, as compared with 958,408 in the previous year, and 373,832 in 1867-8. Thus, in only nine years the number of messages has more than trebled. At the end of 1876-7 the system of the Indo-European Government Telegraph Department embraced (1) the Persian section of 792 miles of of land line, and (2) the Persian Gulf section, which included 1,732 miles of submarine cable, and 718 miles of land line on the Mekran coast. The only increase during the year was a length of three miles, due to alteration effected in the Mekran coast line. Two wires run throughout the entire length of the land lines, and there is besides a third wire attached to the posts in the Persian section. This third wire is according to treaty devoted entirely to Persian local work, and is not an intrinsic portion of the Indo-European system; but it is a valuable aid in cases of accident to the other wires. During 1876-7 the substitution of iron for wooden supports was brought to a completion in the Persian section, and the cases of wilful damage, which in former years caused excessive trouble and anxiety, were comparatively few and trifling, partly owing to improved conservancy arrangements, and partly to the disappearance of some of the greatest culprits in the way of pole-shooting. There were two instances of wilful damage to the main cables in the Persian Gulf, and some of wire-cutting on the Mekran coast line. Interruptions on the Persian section aggregated as follows:—One wire, 19 days 23 hours 13 minutes; two wires, 3 days 15 hours 30 minutes; three wires, (involving a total cessation of communication), 20 hours. The longest period during which communication was entirely suspended was 5 hours 10 minutes on October 5, 1876. Violent gales caused the complete breaks. In the Persian Gulf section the interruptions amounted on the cables to 30 days 1 hour, and on the Mekran coast line to 14 days 9 hours 13 minutes; but the existence of the double chain of communication prevented any stoppage of the traffic, and there was scarcely any appreciable delay, one or other of the lines being always in good order. But although the total interruptions in Persia and the Persian Gulf did not arrest traffic for more than 20 hours during the entire year, yet the business of the department was stopped for upwards of 20 days by the frequent breakages on the Gitomir-Tiflis section of the Indo-European Telegraph Company's wires. The aggregate interruption of traffic between England and Karáchi amounted, therefore, to 21 days. Speed was well maintained throughout the year, the rate at which the traffic was transmitted averaging only 1 hour 35 minutes per message between the United Kingdom and Calcutta. This was the highest speed ever reached, and exceeded by eight minutes the pace attained on the Suez route. The tariffs and regulations of the St. Petersburgh Convention remained in force during 1876-7, the charge between India and Europe by the Tehran and Suez routes being $2\frac{1}{2}$ rupees per word. The introduction of the word tariff, which came into force on January 1, 1876, appears to have been much appreciated by the public. Messages under 10 words in length formed 35 per cent. of the whole number. Altogether, 45,205 messages (containing 883,913 words) were transmitted by the departmental cables. Of these messages 37,415 passed between Europe and India, and 4,950 between Europe and the far East. The numbers sent by the Red Sea route during the same period were 56,862 and 23,977 respectively, or a total of 80,839. According to the Finance and Revenue Accounts for 1876-7, the revenue receipts of the Department were £87,609, and the charges £72,702.

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USEFUL EFFECT OF MAGNETO-ELECTRIC MACHINES.

BY M. A. ACHARD.*

The improvements made in magneto-electric machines during the last few years have given a new impulsion to the endeavours made to extend the use of the electric light, and have consequently led to various experiments for comparing the mechanical work absorbed by these machines with the intensity of the light obtained through them. But the production of light is only one special application of the current supplied by them, and it may be useful, from a general point of view, to consider these machines with reference to the current generated by them under given conditions, or, to speak more accurately, from the point of view of their *useful effect*.

In the first place, we must define what we understand by this term.

When the current from a battery is not employed in the production of any mechanical work, the heat disengaged in the whole circuit in unit time is the exact equivalent of the net positive work due to the chemical affinities acting in the battery; and we know that, in accordance with Joule's law, this heat is proportional to the total resistance of the circuit and to the square of the current.

But the electromotive force (E) of the battery may be considered as constituting the difference of potentials which determines the movement of electricity; so that, if we multiply this by the intensity (I) of the current—that is to say, by the quantity of electricity passing in unit time, the product E I represents the work that the electric current can, in one form or another, accomplish in the same time. Since, according to Ohm's law, we have $E = I R$, R being the total resistance of the circuit, this product may be also expressed by I^2R. This value $I^2 R$ is thus homogeneous with a quantity of work; it represents a certain work expressed in a unit which depends upon the units adopted to express I and R; and when, in accordance with Joule's law, we express by $A I^2 R$ the quantity of heat evolved per unit of time in the whole circuit, under the conditions indicated, the ratio of proportionality A is simply the *thermal equivalent of work* referred to the unit of work in question.

If the current, instead of being produced by a chemical action, like that of a battery, is produced by a mechanical action, the product $I^2 R$ preserves the same signification. It constitutes, therefore, the *absolute useful effect* of a magneto-electric machine, provided we include in R the resistance of those portions of the circuit, whether fixed or movable, included in the apparatus itself. But here a loss of work takes place, in virtue of which the product $I^2 R$ is necessarily less than the work (T) expended in unit time to drive the machine. The ratio $\frac{I^2 R}{T}$ will thus represent the relative useful effect, or the *yield* of the machine. It is this ratio which we require to know in the case of the various machines in use; it would be one of the principal elements from which their comparative merit may be arrived at.

Among the experiments made by Prof. Hagenbach with a Gramme machine, there is only one in which he gives the result of a dynamometric measurement. But this was an experiment in which light was produced, and it is a question whether the irregularity in the resistance of the voltaic arc does not render the experiment valueless.

M. Hagenbach having this year commenced some fresh experiments with a Gramme machine, was good enough, at my request, to supplement, by dynamometric measurements, some of the experiments made by him without production of light, and we now give the results. These we have translated into absolute (centimetre-gram-second) units, from which the yield was afterwards deduced.

The resistances supplied by M. Hagenbach are expressed in Siemens' units, and this unit is equal in absolute units to $\cdot955 \times 10^9$ ($\cdot955$ ohm); the current intensities are expressed in chemical units corresponding to 9 milligrams of water decomposed per *minute*, and equal consequently to $\frac{9}{60 \times \cdot937} = \cdot1601$, since the absolute unit of current represents $\cdot937$ miligrams of water decomposed per *second*. These reductions being made, the product $I^2 R$ will be expressed in absolute units of work, of which the value in relation to the kilogrammetre is $1 : g \times 10^7$, g being the value of gravity in metres.

(The table in next column gives the results thus deduced from the experiments of M. Hagenbach.)

The discrepancies in the "yield" are sufficiently obvious. But it is unnecessary to investigate their origin, since, according to M. Hagenbach, the dynamometrical trials were not made under sufficiently exact conditions. A Prony break was used in these trials, and there is no doubt but that it would have been better to employ a registering dynamometer, measuring the work expended during the actual movement of the apparatus by which it was consumed, rather than a break measuring, before or afterwards, the work supplied by the motor.

Nevertheless, we have thought that it might be useful to publish these results, as being approximative.

The useful effect of a magneto-electric machine being thus defined, let us consider an entirely different question, to which great interest attaches at the present moment—that of the efficiency of these machines for obtaining light. This efficiency depends not only upon the useful effect, which is one of its factors, but also on several other circumstances. There are here two cases to be distinguished.

	1	2	3	4
Velocity of the Gramme machine. Revolutions per minute.....	935	919·5	900·5	893
Value of R* in absolute units of resistance	$2{\cdot}435 \times 10^9$	$3{\cdot}648 \times 10^9$	$4{\cdot}718 \times 10^9$	$5{\cdot}787 \times 10^9$
Value of I in absolute units of current	2·828	1·759	1·295	1·005
Value of $I^2 R$ in absolute units of work.....	$1948{\cdot}6 \times 10^7$	$1129{\cdot}2 \times 10^7$	$791{\cdot}3 \times 10^7$	$584{\cdot}9 \times 10^7$
Value of $I^2 R$ in kilogrammetres...	198·6	115·1	80·66	59·62
Value of I in kilogrammetres	301·5	141·0	86·2	83·2
Yield $\left(\frac{I^2 R}{T}\right)$	65·9 per c.	81·6 per c.	93·5 per c.	71·6 per c.

The simplest is that of the production of light by simple *incandescence*. In an unbroken circuit a conductor, having the resistance r, is inserted; so that, if we call R the resistance of the remaining portion of the circuit, the total heat evolved in unit time is $A I^2 (R + r)$, or $A k T$, k being the yield as above defined. The portion of this heat which is evolved from the conductor is $A I^2 r = A k \frac{I r}{(R + r)}$, and, if this conductor be of sufficiently small mass and specific heat, its temperature may be sufficiently elevated to render it luminous. If we represent by f the luminous intensity (expressed, for example, in Carcel *becs*) which corresponds to a unit of heat, the light obtained will be $f A k T \frac{r}{R + r}$, and the quotient of this quantity by the work expended (T)—that is to say, $f A k \frac{r}{R + r}$, will be the *yield of light*.

It need scarcely be pointed out that f is not a constant. This coefficient becomes augmented, and consequently the yield of light is also augmented, as the heat produces a more elevated temperature—that is to say, other things being equal, as the current becomes more intense. There is no other limit, except the temperature at which the conductor would fuse.

The second case, more complicated, is that of ordinary electric lighting, where the current, traversing the space between two conducting electrodes (in practice these are points of prepared charcoal), forms what is termed the *voltaic arc*.

Before proceeding, it is necessary to refer to the mode in which the principle of the equivalence of the effects of forces is formulated when the electric current, instead of exclusively producing heat, produces some form of mechanical effect.

The machine possesses an electromotive force which varies with the velocity, but which, for a given velocity, has a determinate value. The effective work (that is to say, the product of the gross work by the *yield*) is equal, so long as the velocity does not vary, to the product of the corresponding electromotive force (E) by the intensity of current obtained. If, then, we obtain a current I, with the velocity to which E corresponds, and if the sole effect produced be the heat (Q) developed in the circuit, we have

$$k T = E I \frac{Q}{A}.$$

But if we employ the current to produce some other effect having (W) for its mechanical equivalent, the velocity of the machine and the resistance remaining as before, the heat developed in the circuit diminishes, as well as the intensity of the current and the work expended. We then have

$$k T_1 = E I' = \frac{Q'}{A} + W.$$

* Translated from the *Archives des Sciences Physiques et Naturelles*.

* These values of R include $\cdot44 \times 10^9$ for the resistance of the movable coil, and $\cdot59 \times 10^9$ for the resistance of the wire upon the inducing electromagnets, total $1{\cdot}03 \times 10^9$. The difference is the resistance of the external portion of the circuit.

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In virtue of the laws of Ohm and Joule, Q′ has the value $A E' I'$, E′ being the algebraic sum of the electromotive forces acting in the circuit, and I′ the new value of the intensity. Thus $k T_1 = E I' + W$.

We see, therefore, that E′ is not equal to E but smaller, and that, consequently, there intervenes an electromotive force $F = \frac{W}{I'}$ opposed to E and equal to the excess of E over E_1. We may, therefore, write $k T = (E - F) I' + W$.

This is what occurs when W represents the work accomplished by an electromotor, or the chemical work of an electrolysis; we know that F is an electromotive force of induction or of polarisation, according to the conditions.

If the production of the voltaic arc gives rise to any mechanical work, it should also occasion an electromotive force opposing that of the principal current. Now, the existence of this force has been established by M. Edlund*, and the work to which it belongs consists in the tearing off of the molecules removed from the electrodes by the current, and serving as the vehicle for its transmission across the space necessitated for the production of the arc. The theory which we have just summarily referred to is thus applicable to this case.

Since we have $F I_1 = W$, the equation above may be written $k T_1 = I_1^2 (R + r) + F I_1$, or, since the current is reduced from I to I_1 by an opposing current of the intensity $I_2 = I - I_1$, determined by the intervention of the electromotive force F,

$$k T_1 = (I - I_1)^2 (R + r) + F (I - I_1).$$

It will be understood that r designates the supplementary resistance residing in the arc itself and which would be suppressed if the electrodes touched each other, and that the intensity I is that of the current which would be produced if, in suppressing the arc, a wire of equal resistance were inserted in the circuit, so as still to have $R + r$ for the total resistance. Since we have then in virtue of Ohm's law, $I = \frac{E}{R + r}$ and $I_1 = \frac{F}{R + r}$, whence $I - I_1 = \frac{E = F}{R + r}$, we may write $k T_1 = \frac{E (E - F)}{R + r}$.

The heat produced in the arc will be:—

$$A (I - I_1)^2 r = \frac{A (E - F)^2 r}{(R + r)^2},$$

the ratio of this heat to the work expended (T_1) will be

$$A k \left(1 - \frac{F}{E}\right) \frac{r}{R + r},$$

and, representing by f the variable coefficient already defined, we have for the *luminous yield*

$$f A k \left(1 - \frac{F}{E}\right) \frac{r}{R + r}.$$

The mass in which the heat produced is generated, and which is raised in temperature by this heat, is composed essentially of the particles torn from the electrodes. The heat of the arc is proportional, other things being equal, to the square of the intensity of the effective current $I - I_1 = I_2$; if the mass of the molecules torn off is constant, or at least if it increases less rapidly than the heat of the arc, as is probably the case, the temperature of the arc, and, consequently, the coefficient f will augment with the intensity of the current.

It is evident, from what has been said above, that the voltaic arc can be produced only by obtaining from the machine employed an electromotive force superior to F; and the presence of the factor $I - \frac{F}{E}$ in the expression for *yield* shows that the latter becomes greater as the excess of E over F is greater. It would appear to result from the researches of M. Edlund that F is not a constant, but augments with the intensity of the effective current, whilst at the same time it tends towards a certain limit. This limit seems to be the equivalent of the electromotive force of about twenty-one† elements of Bunsen, and we know that the electromotive force, in absolute measure, of one of these elements varies from $1{\cdot}63 \times 10^8$ to $2{\cdot} \times 10^8$.

What is evidently required to complete this theory is to know the law which relates F to $I - I_1$ and to introduce it in the factor $I - \frac{F}{E}$.

To resume: whether in the case of simple incandescence or in that of the voltaic arc, the luminous yield depends, in the first place, upon the ratio $\frac{r}{R + r}$ between the resistance of the luminous portion of the circuit and the total resistance, and, secondly, upon the coefficient f, which, itself depending upon the ratio of the heat in the luminous portion of the circuit to the mass of the latter, will augment with the intensity of the current. In the case of the voltaic arc, it depends, moreover, upon the factor $1 - \frac{F}{E}$, which itself increases with this intensity.

It will be seen, therefore, that, in obtaining light, it is advantageous to employ the most intense currents, and consequently the most powerful machines, as experience has amply shown.

The necessity of having to overcome the electromotive force F in the case of the voltaic arc appears to indicate that this form of light is that which least readily lends itself to subdivision. From this point of view it would be useful to investigate whether this force decreases indefinitely with the intensity of the current, or whether it can never fall below a certain minimum.

* See Poggendorff's "Annals," vols. cxxxi., cxxxiii., cxxxiv., and cxliv. ("Archives," vol. xxxi. and xxxii.)

† This figure is applicable to electrodes of retort carbon. With electrodes of copper it would be only 18 elements.

SOUTH AFRICAN TELEGRAPHS.*

The great guiding principle adopted in the construction of the telegraphs of South Africa has been to have everywhere alternate routes, so that in case of the connection between two places upon a trunk-line being intercepted, communication can still be maintained between them in a roundabout way. The importance of thus having two strings to the bow is always kept in mind in railway construction, but it is exceptionally pressing and great in the case of South Africa, where the exigencies incident to passing through districts occupied by a capricious and not always contented and orderly native population have to be provided for. The country happily lends itself very readily to this necessity.

Pretoria, in the Transvaal territory, occupies the apex of a triangle, which is connected by two of its sides with Natal and Cape Town. When all the lines which have been projected have been completed, there will be hardly a town of any importance along these routes which will not have the advantage of a second method of communication, and with many of them there will even be a third. With such a system of connection, the Griquas might destroy many miles of wire without interrupting the communication between Natal and the Cape; or the Zulus in the disputed territory on the Blood River might destroy the section across the Drakenberg, and yet the connection between Natal and Pretoria be unbroken. From Cape Town the completed line runs north-eastwards, not far from the coast, through Kokstadt to Maritzburg, giving off seaward branches to Algoa Bay, Port Alfred, East London, and Durban, continued on to Stanger, in the Victoria County of Natal. An alternative upland line runs through Beaufort West, so as to form a junction with the lower line at Beaufort, giving off branches northwards, or inland, to Ceres, to Victoria West, to Kimberley, in the Diamond Fields, and to Aliwal North. From this completed line there are to be extensions to Bloomfontein, through Kimberley on the one hand, and through Aliwal North on the other; and from Bloomfontein the line will proceed to Pretoria, to which there will also be the alternative route, already in a forward state, through Maritzburg. The completed line, it will be observed, connects Cape Town with the western provinces of the Cape, Griqualand, Kafraria, and Natal, and the next extensions of the line will connect Pretoria (Transvaal), through Bloomfontein (Free State), with Kimberley, and by the alternative, and more roundabout route, through Natal, which will pass by Ladysmith and Newcastle.

In referring to the plan for telegraph construction in this district, it is happily not necessary to fight over again the old battle of road and rail, because railway construction is here yet in its earliest infancy, and already far outstripped by the telegraph. The lines of the telegraph, nevertheless, take broadly the routes which railways will ultimately follow. New stations from these will be easily supplied by short loops from the trunk lines. In the selection of routes in a country like Africa, the fate of the chosen line does not hang upon the will of petty landowners, or of crotchety householders. The field is quite clear of this form of difficulty. It is the plethora of land, and the bounteous freedom of choice, rather that presents itself as an embarrassment to projectors.

In the line first constructed, between Port Elizabeth and Cape Town, by the Messrs. Siemens Brothers, it was thought advisable to conceal the posts and wires as much as possible from traversed roads. It is not quite easy now to understand why this should have been done. But the line as made is certainly a

* By J. Sivewright, General Manager of Telegraphs in South Africa. Communicated by Robert James Mann, M.D., to the Society of Arts.

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good and successful one. The 500 miles of the line can only be, as a rule, followed on horseback at a walking pace, and in many parts the country traversed is impracticable by a horse, and occasionally even finds work for an expert in mountain climbing. The notion, however, that such a course was requisite to guard against wilful damage will not bear scrutiny. Wooden poles and iron wire are not of sufficient intrinsic value to stimulate theft, and the insulators are absolutely of no other value than the purpose to which they are applied. Wilful damage is far more likely, in truth, to be attempted in hidden kloofs and out-of-the-way places than on routes visible from a high road. Thoughtless and undesigned injury is also more easily stopped in situations that are open to watching. The prime cost and after maintenance is certainly less along an unconcealed course, and faults are obviously more easily rectified, and impending break-downs more readily foreseen and provided against. Traversed roads also invariably strike the "drifts," or fords, of rivers at the most convenient and accessible places. They are always found where the bed of the stream is the least confined, so that the waters can spread out and admit of a shallow crossing. In the line which has been alluded to the lineman in many places cannot follow the wires across rivers without making detours of many miles. Zealous officers have actually upon occasion been swept away in the attempt to make a direct and immediate passage of the river.

The argument for following roads, however, loses much of its force in the grass uplands of the eastern province, on the plains of the Orange River Free State, and along the low rolling hills of the Transvaal. A bullock waggon, with the engineers' stores, can there make its way anywhere, and travellers on foot, or cantering on horseback, commonly prefer to strike across the open country rather than to follow the waggon track. The same state of matters prevails in many parts of Kafraria and Natal. Hence the advisable course in laying down a new telegraph route seems to be:—1. To follow the highway, and to keep within sight of it in the bush, or bush veldt; and, 2. To take the shortest available route which, with due regard to good river crossings, can be taken by waggons or horsemen over the grass veldt.

The choice between timber and iron for posts is a matter which requires some consideration. The general and obvious disadvantages of timber are that it is liable to decay, to ravages from insects, and to accidental injury from bush fires. In districts destitute of wood, wooden posts are liable to be cut down for firewood. They are also convenient for the renewal of disselbooms, or poles of waggons, in case of accidents, and useful as shed supports, and are applicable to various other purposes. Iron posts, on the other hand, entail a large prime cost, and have their own electrical disadvantages in damp weather. Perhaps the best practical rule under the circumstances is to use timber for posts wherever it can be easily obtained of good, sound quality; and, when this cannot be managed, to employ iron. Timber, not of the best quality, may also be turned to good account by adopting an organised system of maintenance, which includes "spurring" of posts at the wind and water line. It should never be forgotten also that in all new countries it is very advisable to make the largest possible use of natural products for public works. It is wise to keep the money circulating in the country, instead of sending it out in exchange for iron telegraph posts. This principle, of course, must be adopted discreetly, and not carried to an absurd extent.

In the western province suitable wood is not readily obtained. The fir grows near Cape Town with great rapidity and luxuriance; but on that very account it is open grained, and with the sap never really down, so that it is altogether unsuitable for posts in its natural condition. Creosoting, which is the only reliable method of preservation, is out of the question, because creosote is not to be procured in the colony, being an exceedingly objectionable article for shipment. It is found more practicable to import creosoted timber for posts, than to prepare it by creosoting native timber on the spot.

The silver-fir grows vigorously on the slopes of Table Mountain, but there is only a very limited supply. Oak, in any quantity, is not to be had. The Australian blue gum, which is largely grown, is not of suitable quality.

In the magnificent forests of the Knysma and Zitzikamma there is a wood which is of slow growth, and which is saturated by a permanent oil that renders it very durable. This is known as the "Waar olyven hoot," or olive tree. The timber is of quite unexceptionable quality, and if plentiful would at once altogether banish iron. Unfortunately, however, in this climate, where nature runs to riot in luxuriance of vegetation, slow growing plants are stunted in their development, and assume the proportions of large bushes instead of becoming trees. Olive wood, of adequate size, is on this account, not abundant. It is used when found of sufficient size, and then, even after eighteen years, shows no trace of decay between wind and water. It is, however, apt to warp above, and to split round the bolts. Iron wood, known as black iron wood in the Knysma, and as hard pear wood in the Zitzikamma, is procured, but not in large abundance, from the same district. It is also very durable, and furnishes poles twenty-one feet long, eight inches square at the base, and tapering to four inches above.

In the eastern province sound timber of good quality, sufficient size, and adequate abundance for practical use, is first met with. It occurs in the form of what is known as the umtatie, or sneezewood, on account of the snuff-like properties of its irritating sawdust. It is of slow growth, and is charged with a permanent oil. Trees twenty-one feet long, and with a circumference of twenty inches at the base, must be at least sixty years, and, according to some authorities, are not uncommonly a complete century, old. The so-called oleaginous constituent is in reality a resin which is soluble in alcohol. Sneezewood poles are crooked and unsightly, but their ungracefulness is fully compensated for by their excellence. The tree, as it grows, is composed of bark, sap-wood, and heart-wood. In poles cut from the tree, about half an inch of the outside is generally sap-wood, which loses its sap after a few years, and may then be easily removed. The heart-wood which remains is practically indestructible. In 3,000 poles examined, which had been in the ground from ten to sixteen years, there was not one which manifested any traces of decay. A piece cut from an old pole burns as brightly as fresh resinous or creosoted timber. Sneezewood poles on this account are very convenient for lighting camp fires. Hence, established places of outspan should be scrupulously avoided in laying out a line. The crookedness of the pole happily makes it less desirable for the renewal of disselbooms.

The destructive influence of grass fires can be effectually guarded against by clearing a space 12 feet in diameter round each pole and maintaining the clearance. No instances are known where poles protected in this way have been destroyed. Sometimes they get charred by the heat, but they do not take fire on account of the rapid passage of the flames.

The average weight of the sneezewood pole of the dimensions specified is 225lb. For lines far inland, on this account, iron has an advantage. The distance from a forest at which iron may be advantageously substituted for timber, depends to some extent upon the cost of transport. Three years ago, when the line to the Diamond Fields was constructed, each iron pole, at its peg, between Colesberg and Kimberley, cost the contractor 50s. At the present time sneezewood poles are furnished on the Faure-smith-Bloomfontein Section, 250 miles from the base of supply in the forests of the Amatola Mountains, at 40s. each. Transport rates, however, have been higher in most parts of South Africa during the last season than ever known to be before.

In regard to iron poles, lightness and strength are the qualities which have to be aimed at. The ribbed base, or buckle plate, with a ribbon-shaped tube fitted to carry two or three wires, is a commendable form. In a grazing country, cattle make less use of iron than wood as rubbing posts. They dislike both the heat and cold of the iron. Wooden poles are very commonly made quite smooth by the rubbing of cattle.

The wire in general use in South African telegraphs is galvanised iron of No. 6 gauge. Each section has to be looked at as one link in an extended, and still possibly extensible, chain. It does not, therefore, do to adopt any smaller gauge. There is an old form of ungalvanised wire, which was used by the Siemens Brothers in 1873 between Fort Beaufort and Colesberg, which has answered very well. One thing which is especially needed for service such as that in South Africa, is some light kind of compound wire with relatively small resistance, such as the steel wire coated with copper not long ago invented. The transport factor varies, it must be remembered, directly in proportion to the gauge. The lighter wire also implies the employment of lighter poles, lighter insulators, and a general reduction in the weight of fittings. The momentous importance of this point will be at once understood, when it is stated that transport at the present time is at ruinous rates. On the 9th of December last the rate from Durban to Maritzburg, a distance of fifty-four miles, was £15 10s. per ton. An occasional waggon could at that time be had, as a matter of favour, to take a load up to Pretoria, in the Transvaal, a distance of 450 miles, at £52 10s. per ton.

(TO BE CONTINUED.)

THE ELECTRIC LIGHT ON THE EMBANKMENT.—The agreement entered into for an extension of the lighting of the Victoria Embankment with the electric light is that twenty lamps shall be placed between Waterloo and Blackfriars Bridges. The electric light, with forty lamps from Westminster, will thus be applied over a distance of 2,145 yards from one centre, worked by Ransome's series of 20-horse power engines and two Gramme batteries.

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THE PROPOSED NEW ATLANTIC CABLES.

We are glad to find that, in relation to this project, those interested in the present Atlantic cables are speaking with no uncertain sound. The chairman of the Direct United States Cable Company, at the ordinary meeting reported in our issue of March 20, and, again, the chairman of the Anglo-American Company, at the meeting reported in to-day's issue, have spoken against the scheme. We have, when previously discussing this question, stated our firm conviction that not only was there no present need for any additional Atlantic cables, but that the carrying out of the proposition to lay two more cables would result in an enormous loss to those confiding purchasers of shares who listen to the voice of the promoting charmer. It was stated at the meeting of the Direct Company that the capital required by the promoters in France was about £2,000,000, and that two cables could be laid for something like £400,000 less than this sum. The pertinent question was asked, what is to become of this extra £400,000? Is it possible that the promoters are actuated entirely by philanthropic motives, and that any sum over and above the actual contract price will be placed so as to form the nucleus of a reserve fund. Let us hope this is so, and that the future will not find the £400,000 added to the balances held by the promoters in various banks. We hope the following considerations will be brought before the French public. The shares of the Atlantic cable companies can now be obtained at 40 or 45 per cent. below their nominal value, and *à priori* the £2,000,000 of capital of the new company will be found to have a market value, as soon as quotations are made, of about £1,000,000 only. The fact is clear to any one who cares to take five minutes' thought, and thus we can only class the promoters of such a scheme with those who would boldly ask for a million pounds to throw into the crater of the Mauna Loa, in order that a native of the island might see it melt. The career of a financier who attempted to float a company for such a purpose would be worth careful study. That we do not exaggerate will be seen from the following extract from Mr. J. Pender's speech at the meeting of the Direct United States Cable Company. Referring to interviews with the promoters in Paris he said:—"We showed them that they were bringing before the public a scheme with a capital of upwards of £2,000,000 for two cables, or, say, about double the capital of the Direct Company. I told them plainly that our Company had many advantages in its greater security from its connection with the Anglo Company, and that in every sense it was a much more valuable property than their new cable could be, but that the shares of the Direct Company at the time I was speaking to them were at a discount of close upon 50 per cent. I pointed out that the company, if brought out, must of necessity come down to the same level, and that, if they persisted in their scheme after this information, the moment their cable was laid competition would arise, a 1s. or probably a 6d. tariff might be adopted; and, although there might be a diminution in our receipts, it would entirely prevent the new company from paying one shilling to their shareholders, and the result we should look for would be that we should in time, if we chose, become possessed of their cable at least 50 per cent. cheaper than a new one would cost. I pointed out to them that there was no necessity whatever for the laying of a new cable, seeing that the existing cables were equal to three or four times the amount of work now offered, and, seeing that the Anglo and Direct Companies have both applied the duplex principle, their carrying power had been very greatly increased." Mr. Pender also referred to the probable income of such new Company, in the absence of any competition. The student of mathematics, who will trouble himself to do so, can easily calculate the chances of obtaining a certain income. The facts upon which his calculations must be based are well known, and may be simply stated. The number of cables now working across the Atlantic is four, the addition of two more gives six. Supposing that the ability to obtain business was the same throughout, the total business, and, therefore, the total income divided by six, would give the probable income

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of each cable. But, according to Viscount Monck, the chairman of the Anglo-American Company, all things are *not* equal, and the existing companies have special and advantageous agreements, which make it almost certain that their cables would earn more than one-sixth of the total per cable. He said, "This Company and its colleague, the Direct Company, had by special agreements the right to bring almost every message which crossed the Atlantic from America here, and they had priority in, he believed, all European countries over any other company which might exist—that was to say, the Governments of all European countries, France included, were bound to send all messages transmitted to them by these two companies' lines, unless the sender directed to the contrary. Did any reasonable man think that 8 per cent. would be a fair allowance to make for these enormous advantages? But even such an allowance would reduce M. Pouyer Quertier's proportion of the traffic from one-third, or 33 per cent., to 25 per cent. In his prospectus that gentleman coolly and quietly said he expected to get 48 per cent., but he had dropped down to 40 per cent. Viscount Monck asserted, however, that he would not get more than 25 per cent., or £178,750. The working expenses, taking the expenses at one-third more than those of the Direct United States Cable Company, who worked only one cable, would be £67,000, the reserve, which should be laid by in the same proportion as the Anglo and Direct Companies adopted, would be £100,000, and M. Pouyer Quertier's own estimate for the redemption of his bonds was £32,000, making in all £199,000, or about £11,000 more than he would receive as his share of the traffic." The directors of the existing companies, considering the property of their shareholders, have taken preliminary steps to establish a separate French Company with a French Board of Directors, to which the French Concession held by the Anglo-American Company and the working of the Brest, St. Pierre, and Duxbury Cable should be transferred, and thus to meet the national sentiment of the French people, that their transatlantic communications should be under French management.

It is greatly to be deplored that a few individuals, who, whatever may happen, will take care to lose nothing themselves, should be able to interfere with the present satisfactory cable work across the Atlantic. We imagine that when the whole secret of the proposal of this absurd scheme is known, it will be found to have proceeded from a source far different to that of French financiers. It is hardly credible, however, that personal feeling against the Direct United States Company should be at the root of all, and yet this is what has been stated. We trust that the capitalists who favour this scheme will again and again consider that an increase of cables does not mean an increase of business, but increased and determined competition and opposition, which must ultimately end in the ruin of trusting shareholders. The existing companies have their business, their rival has to obtain a business. The agreements in existence cannot be modified for many years to come, and probably, the clients being well served, there is no wish to modify them. The cables now laid are more than sufficient for all they are called upon to do, and when the time arrives that business is retarded by the great increase of messages beyond the carrying capacity of these cables, then and then only would it be justifiable to ask the public to contribute more capital to be devoted to cable work. In a word, the cables are not wanted, there is no new work to be obtained by laying them, and to adopt such a course would be to violate the principle of political economy that capital should be used productively.

CORRESPONDENCE.

ELECTRIC POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is to be hoped that the result of the discussion upon this subject now going on will be to bring some few others into the happy condition of the author of the article p. 231, who has after long labour succeeded in gaining a "tolerably clear conception of potential." But here is the very gist of the objection to the use of this term, and it may even be said to the acceptance of the idea which the term is supposed or intended to convey. Is it desirable to introduce into electrical science a term which involves such "long labour and thought" on the part of men of severe mathematical training, possessed of natural intellect far above the average? especially as it is impossible to meet a clearly intelligible definition, or to find two definitions which entirely agree. I, too, have given a good deal of mental labour to endeavouring to get a clear conception of the subject, and though I am not in the happy condition of Prof. Baynes, I have penetrated far enough into the mist to understand that he gives us the clearest view of the subject as yet presented. But he proves the justice of the remarks I made (p. 154 of "Electricity; its Theory, Sources, and Applications") to explain why the fashionable term potential was not employed in that work. "At present it has really no definite and accepted meaning." "The word is almost always used in place of tension and electromotive force, because there is something full and smooth-sounding about it; but the idea which really does belong to it is a pure mathematical abstraction which only highly-trained minds can apprehend."

It is true that Count Du Moncel tells us that the term is "indispensable to those concerned in exact science, and can be criticised only by those who are unacquainted with the accurate definition of the term in question." All things considered, it is, perhaps, no great stretch of humility to rank oneself among these, for, not to travel out of these pages, we find Du Moncel himself, p. 131, tells us "the potential of an electric source depends upon the tension." M. Abria "defines it by stating that the potential of an electrified body is the indication of a torsion balance." (This definition is slightly puzzling). Then Dr. Lodge, pp. 164, 187, while adopting Du Moncel's other definition, that potential is to electricity what temperature is to heat, classes others of his statements in the genus "nonsense." Prof. Baynes follows by remarking that the learner gets his mind thrown "into utter chaos" by the imperfect definitions given, *especially in mathematical books!* There really is some excuse for looking somewhat shyly at a tool of thought so exceedingly apt to turn round and cut the workman's fingers. But the fact of the matter is that the mathematics of the present day are developing fast into metaphysics, and its advanced disciples seem to be losing themselves in "space of four dimensions;" their modes of thought and style of dealing with natural problems unpleasantly resemble the old style of "philosophy falsely so called," with its jargon of "substance, form, accidents," and so on. The electricity of the text books, and of mathematicians, is purely a creation of the imagination, evolved out of the inner consciousness, like the the German's well-known camel. Thus, Prof. Baynes begins his definition by saying, "Let w be the work done in bringing up a charged particle from rest, at an infinitely distant point A to rest at a point B on the charged body." There is a nice little strain upon the inner consciousness. We must conceive these two bodies isolated in infinite space, thereby annihilating all other existences, and then expend work in bringing them together. But electricity, such as it exists in nature, could not be got upon those two bodies at all. Here, indeed, is the very secret of this "potential" question. Those who oppose the word do not object to it merely as a term, further, that it has no necessary position to fulfil, excepting in what I sometimes call intellectual gymastics, and which Mr. FitzGerald speaks of as "those purely mathematical exercitations which delight certain theorists." The objection is that the word is typical of a system which tends to divorce science from nature, and to substitute formulæ for facts, and processes which are merely arithmetical calculations for theories of nature's order of operation.

More and more are students led to fix their thoughts upon *the* electrical charge, that is upon a charged body, instead of upon the real truth that no one ever yet saw such a body. They are taught to think of the "capacity of a surface" while in actual nature *a* surface has no capacity whatever. Thus the absolute dual nature of electric charge is kept out of view. Students are taught that electricity resides upon surfaces, and to expend a great deal of ingenuity over the distribution of the charge; as a consequence, few understand that the true electricity exists not as a *single*

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charge upon one surface, but in the intervening space between the *two* surfaces which officiate simply as collectors, just like the anode and cathode of a decomposition cell. Hence it comes about that static electricity and dynamic electricity appear to belong to two distinct universes, and the elaborate scaffolding erected about the first becomes not merely useless but an encumbrance when we want to build up a theory of the other. It is actually in electrostatics (and the artificial electrostatics of the mathematician) that the true idea of "potential" has its place; in dynamic electricity it is almost impossible to locate it except by jostling our old friends, electromotive force and tension, out of their places; actually, potential is used to combine and substitute both these terms, and so do away with a very useful distinction between the origin and the manifestation of electric action.

Professor Baynes has given an expression of electric potential which is of greater moment than it would appear he attributes to it himself, as $M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-1}$, which he says, *for ease of remembrance*, we may notice is $\sqrt{\text{force}}$. Now, if we modify this last to $\sqrt{\text{energy}}$, as expressed, say, in footpounds or gramme metres, or in that objectionable and most unnecessarily confusing centimetre system (devised, apparently, merely for complication and extra trouble), we have a real truth, not something to be used for ease of remembrance as an offshoot of the mathematical system. It is a physical fact that what we call potential electromotive force or tension is simply the square root of the energy expended upon the circuit or available for expenditure, and in that sense "potential." That is a fact, linked to the similar fact which I put forth lately in an article upon resistance, that the diminution of current by work done in the circuit is expressible as a resistance in ohms in terms of the square root of the work done, or as a counter electromotive force in the same terms. Writers on potential are apt to work in a vicious circle; they define difference of potential as the cause of current, and say that currents cannot occur between two points at the same potential, and that all parts of a surface in good electric or metallic connection must needs be at the same potential. Now, if we suspend a metallic sphere in the middle of a room, what happens? We can charge it to a certain potential, *i.e.*, difference of potential from earth, to which, of course, *we are told* the other pole of the source *must* be connected, so that the — electricity may have an opportunity to escape. But by some perversity in this — electricity, instead of escaping, it collects upon the walls of the room. The charge we can put on our sphere depends now mainly on the size of the room. Now, if we bring near it another sphere connected to earth, which really means to the — side of the source, we can get a larger charge upon the first or + sphere, because the inductive resistance is lessened. But in the first case the charge was equally distributed over the surface, while in the second it is collected mainly on the side presented to the — sphere. Now, to explain this simple fact, so clear when we recognise the dual nature of electricity as dependent upon + and — molecular polarity, we are offered a bristling array of terms and formulæ. We are told that all parts of the spheres are at one potential (because that is a necessary sequence of the previous definition of potential); but that the tension is different or its density, and so on. But if we cause the spheres to move, one revolving around the other, the electric charges will travel round their surfaces, and we have electricity moving from point to point, those points being at the same potential. Of course there is no difficulty in giving an explanation, just as in olden times, when some new fact had to be accounted for, the astronomers simply arranged a new curve which was perfectly satisfactory to mathematicians. But all those curves were swept away when the natural truth of the sun's central position was adopted, and so will most of our present electrical elaborations when people look more to physical truth, and depend less upon artifical abstractions.—Yours, &c.,

J. T. SPRAGUE.

ELECTROSTATIC POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was glad to see Mr. Robert Baynes's interesting and amusing article in your last issue. The main point he wishes to bring forward is somewhat minute, and, perhaps, a little more metaphysical than physical (turning principally on the meaning of the word *is*), but I think there can be little doubt that he is quite correct, and that one ought to define a thing as a *property or condition whereby, &c., which is measured in such and such a way*, instead of saying that a thing *is* what it is measured by.

To guard against anyone being misled by the heading into supposing that here is another proof of the (utterly imaginary) disagreement among mathematicians as to the meaning and definition of potential, it may be as well to point out that what Mr. Baynes is tilting against is not any erroneous notion or definition on the part of mathematicians and physicists, but simply a questionable way of *stating* to beginners and learners things about the definition of which there is no uncertainty whatever. Thus *Force*, for instance, is often defined as time-rate of change of momentum; but Mr. Baynes would say (quite rightly, I think, now it is pointed out) "no this is only how it is measured; it is not what force essentially *is*."

But then it is always very difficult to say, except in the vaguest manner, what a thing essentially is; or, indeed, whether there is any objective entity (whatever that means) corresponding to a certain form of words at all. Of certain things, however, we all have a more or less clear experiential notion, as we have of *force*, for instance, through our muscular sense; and the ordinary definition of such things (*e.g.* that force is rate of change of momentum) is not likely to produce confusion.

A learner is more likely to be puzzled if you tell him that the velocity of a body is "the condition whereby it traverses space, being measured by the space traversed per second," than if you tell him that its velocity is the number of feet it goes a second; because the former statement will simply make him (unless he is incapable of thought) wonder what on earth you are driving it, whereas the latter statement will leave him comfortably in harmony with the vague but useful notions which his past experience has hammered into him concerning what *speed* or *velocity* really feels like (if I may use the expression). But when you come to potential, or things of which our ordinary senses and past experience afford us no preliminary notions whatever, then very likely the puzzle may be the other way, as Mr. Baynes says he finds it is. At any rate, the mode of statement which is most correct is undoubtedly the one to be adopted, whether beginners find it difficult or not.

But I cannot agree with Mr. Baynes that the old abbreviated form of statement necessarily led to any erroneous views regarding the *dimensions* of the quantities defined.

First of all, he is thoroughly aware that the definition of potential as "the work which would be done," &c., is only a popular statement intelligible to the non-mathematical learner; and that the real definition is a certain integral about whose dimensions there cannot be the shadow of a doubt. I generally put it thus:—Force is distance rate of change of energy, *i.e.*, if you differentiate the energy of a body in any direction you get the force which urges it in that direction.

Similarly, intensity of force is distance rate of change of potential; *i.e.*, if you differentiate in any direction the potential at any point you get the intensity of the force at that point in the given direction.

Potential is no more the same thing as energy than intensity of force is the same thing as force. Each (if we are speaking electrically) is the other *per unit of electricity*.

The electrostatic potential of a point is equal to (or is measured by, as we will now prefer to say,) the potential energy of unit electricity if placed there; in other or fuller words it is measured by the work that must be done against electrical forces, in order to bring from infinity a small sphere charged with unit quantity of electricity and to place it with its centre at the given point.

Mr. Baynes says "there cannot be any difference in kind between the work done on one unit and the work done on fifty units." Granted. Certainly not! But is there then no difference between work done per unit of something, and work simply? One has always been accustomed to say, Yes, essential difference. For instance: work per unit of time is not work but *power*; work per unit of length is not work but *force*; mass per unit of volume is not mass but density; pressure per unit area is not pressure simply, but intensity of pressure; force per unit of electricity is not force simply but the intensity of the force, often called "the electrical force at a point"; potential energy per unit of electricity is not energy but potential; and so on *ad lib.* I suppose, however, that Mr. Baynes would deny all this: *i.e.*, he would object to the mode of *statement*, not, of course, for an instant to the *facts*; and again I must say I agree with him that a less objectionable mode of statement might be found.

I am amused at his sarcastic observation that he had never before met with the statement quoted mockingly by Mr. Fitz-Gerald that "the capacity of a sphere in space is equal to its radius." He must admit that it *is* equal to it, in dimensions and everything else. It is not the *same thing*. Well, no—few things are. The objection of Mr. Baynes to this statement is comically different from that of Mr. FitzGerald, who has no particular fault to find with the *expression*, but is ready, I fancy, to deny the *fact*.

With respect to Mr. Baynes's last parapraph I am not so clear. I don't think I quite appreciate the difficulty at present, and so I hold my judgment in suspense for further light.—Yours, &c.,

University College, London. OLIVER J. LODGE.

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THE SUBSTITUTION OF "POTENTIAL" FOR "TENSION." TENSION AT POINTED PORTIONS OF A CONDUCTOR.*

TO THE EDITOR OF L'ELECTRICITÉ.

SIR: Allow me to reply to the letter of M. du Moncel which appeared in your last number.† It is true that in my letter I begin by attacking the expression *tension of a current*, and that afterwards I defend the term *tension*, for which some mathematicians have desired to substitute the word *potential*. But it will not require many words to prove to M. du Moncel that there is here no contradiction. (I should here observe in passing that the expression *potential of a current* would be as void of signification as that which occasioned my objection). One might, without any defect of logic, protest against the expression *volume of a surface*, and at the same time approve of the word *volume* in its legitimate application. A point, a surface, an electrostatic charge, may have a tension; but a *current*—the result of a difference of tensions—cannot itself in any sense possess this attribute. In fact, no one has ever been able to give a definition of the "tension of a current." Is this the tension of any given point in the current? No, for this point may have a tension $+x$, or $-x$, or 0, whilst the current remains constant. Is it the tension of one of the poles of the source, when the other pole is connected to earth? No; because if it were so the same current would have an infinity of tensions, since we can obtain any given current with any source, no matter what may be the tension of the pole in question. (Of course, this is provided the resistances in the circuit may be indefinitely varied.—Ed. *E.*) Is it the difference of tensions developed in a circuit? No; for the same reason, and because this difference constitutes "electromotive force," and it will not be asserted that this may be termed also "tension of a current." Is it the difference of tensions measured at the extremities of a given resistance? No; for this constitutes the *intensity* of a current, or the quantity of electricity which passes in the circuit in a second of time.

I thank your learned collaborator—whose opinions, here as elsewhere, command always the greatest consideration—for his declaration that "potential" and "tension" are not two different properties of the electric fluid. Now, to express this *single* property we have no need, at least, in practice, of *two* terms; and it is clear that the word "tension" enjoys a right of priority which should resist any innovation, provided we are careful to give to it an exact definition. I do not speak of a rational or physical definition; for the value of this term *tension*, which itself was imposed upon us by mathematicians, is purely artificial, and expresses only the *square root* of the electrical force which exists in nature. But if, for want of a better, we accept this term, in order to avoid further artificial complications, we should give to it the following definitions:—

1. Tension is that property of electricity which is measured by what is known as the *electrometric* indication. Tension may be positive or negative, according to the sign of the electrometric charge.

2. Let the expression for electromotive force be:—

$$E = \pm T - (\mp T_1).$$

Here the two tensions may be (*a*) positive (*b*) negative, or (*c*) one positive and the other negative, as is expressed by the two signs which precede T and T_1. In the case (*c*),

$$E = + T - (-T) = T + T_1.$$

Thus the general equation, appliable in cases (*a*) (*b*) and (*c*) for one of the *maximo* tensions in any circuit, conductive or inductive, is:—

$$\pm T = E + (\mp T_1).$$

And the equation for the other tension will be:—

$$\mp T_1 = \pm T - E.$$

3. Let $E = Q R$.

Let us call r and r two inductive resistances in series in a circuit (say two condensers having the capacities $c = \frac{1}{r}$ and $c_1 = \frac{1}{r_1}$). Then if we suppose the circuit to be insulated, and that the positive pole of the source is in communication with the condenser having the capacity c,

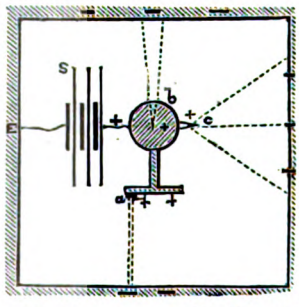
$$R = r + r_1.$$

And the tensions at the two poles will be:—

$$+ T = Q r = \frac{Q}{c}, \text{ and } - T_1 = Q r_1 = \frac{Q}{c_1}.$$

I now come to a question which has been put to me by M. du Moncel, and which is of very great theoretical importance. In the case of a conductor formed with a pointed end, and statically charged, there is escape of electricity by the point, in the form of a brush discharge or silent glow. "Now, in virtue of what force does this discharge take place, if not in consequence of an excess of tension possessed by the fluid at this pointed portion?" I reply that this discharge takes place in virtue of the tension; but that, nevertheless, this tension is absolutely the same at every portion of the conductor. With all due respect to the calculations of the mathematician Poisson, if there were any difference of tensions between one point and another in the conductor, a current would result therefrom, which would have the effect of instantaneously equalising the tensions. Moreover, the electromotive indication is absolutely the same, whether the electrometer be connected to the pointed portion, or to any other part of the conductor. But why, then, should there be a flow of electricity from the point? Simply *because the conductive resistance*, as well as the inductive resistance, *is comparatively very low at this portion of the circuit*. The law is identically the same for these two resistances (R and R^i); that is to say, the same cause which would produce a variation of R would bring about the same variation in R^i. Now the accumulation, or the electrical density, at a given point on the conductor, will be $\frac{E}{r^i}$, if we call r^i the resistance (inductive) which opposes the accumulation of electricity at this point; and the loss of electricity, by conduction, from the same point through the dielectric, will be $\frac{E}{r}$, if we call r the resistance (conductive), which opposes the escape of electricity at this point. Therefore, if the electrical density at a point is very great, we know that the conductive resistance at this point will be comparatively very small, and that a loss of electricity will take place from this point. And, since we know that the electrical density at pointed portions of a conductor is compartively enormously high, and that this density results from the low inductive resistance which here opposes accumulation, we need not be surprised that there should be an escape of electricity from such pointed portions, since the conductive resistance should there be equally low.

But, besides, it is easy to show by the elementary laws of conduction that the resistance opposing the passage of electricity from the pointed portion of a conductor must be comparatively very low, in spite of the high specific resistance of a dielectric considered as a conductor. Thus, in the case of a plane surface, the path, inductive *and* conductive, between a point (or, say, a very small square surface) on an insulated conductor, placed centrally and charged from one of the poles of a source, on the one hand, and the opposing surface in communication with the other pole of the source, on the other hand, will be a line (or a prism of which the cross section equals the small square surface). But in the case of a cylinder, this inductive *and* conductive path (for there is no perfect insulator) takes the form of an angular *surface*, perpendicular to the axis of the cylinder, and having its acute angle at the charged point. (Or, if we take the case of a small square area, this path will have the shape of a cuneiform solid.) In the case of a sphere, this path will take a *pyramidal form* (the pyramid being truncated if we take a surface instead of a point). Lastly, in the case of a pointed conductor, this path, through which electrical action is propagated by induction and by conduction, will take the form of a *cone*, the vertex of which will be more or less obtuse according to the sharpness of the point (this cone being also truncated in the case of the small surface). Now the line (or the prism) represents an enormous resistance, the angular surface (or the solid wedge) a smaller resistance, the pyramid a less resistance still, and the obtuse cone a resistance, inductive or conductive, *comparatively very small*. (The accompanying diagram roughly illustrates the various cases specified, *a* being unit surface of a plane, *b* unit surface of a cylinder or sphere, and *c* unit surface upon a pointed portion of the conductor.)



Need we go any further to explain the escape of electricity, at high tensions, from pointed conductors? Why suppose that the *tension* as well as the *density* is higher at such pointed portions of a conductor than elsewhere, when the electrometer shows that the tension is everywhere the same, or, where there can be any difference, that it is *lower* at pointed than at flat portions of a conductor.

In conclusion, allow me to express here my opinion that the time has almost arrived for the substitution of a physical and natural theory of electricity in lieu of the artificial and provisional theory which mathematicians have given us.—Yours, &c.,

DESMOND G. FITZGERALD.

* Translated from *l'Electricité*. † *Vide The Electrician*, March 22, p. 208.

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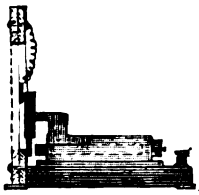
DOWLING'S IMPROVED MICROPHONES.

A new and improved form of microphone has lately been devised by Mr. Frank Dowling. The improvements consist mainly in the use of a thin diaphragm to take up the sound waves, and a magnetic adjustment with which the pressure of the carbons may be varied. The diaphragm may be of animal or vegetable parchment, or thin india rubber, or it may be a thin plate of metal. The vibrating disc is two or three inches in diameter, and screwed firmly between two boards. To the centre of the disc is fastened a small piece of carbon, from which a thin wire passes to one terminal screw. A rod of carbon, about an inch in length, having a piece of iron or steel rod fixed in one end, is balanced on its axle, and rests lightly against the carbon block. A small bar magnet is adjustible by a brass screw either to or from the rod projecting from the balanced carbon, and thus the pressure between the carbons may be regulated.



For transmitting speech it is preferable to have the diaphragm in a vertical position, but for experiments it is horizontal.

This microphone is much more sensitive, and of less resistance than others, and transmits speech perfectly and distinctly. Speaking at a distance of about 200 feet from the transmitter can be heard, and some sounds about a mile distant. With a battery of two cells it will act as a receiver having a similar transmitter. This microphone will receive speech and other sounds. Mr. Dowling considers that this is due to vibrations imparted to the carbon and diaphragm by the *current* itself, the current and vibrations being varied by the transmitter. He is of opinion that this is also the cause of the "singing noises" observed sometimes.

In another speaking transmitter the diaphragm causes a small carbon ball to vibrate in a carbon tube or case. This requires no adjustment, and may be used in any position.

The magnetic adjustment may be applied to ordinary lever microphones, and Mr. Dowling finds it preferable to balance the carbon lever on a vertical axle, the lower axis being pointed and working on a plate. The magnet tends to draw this against a carbon block.

Mr. Dowling has also devised a remarkably small microphone. It consists of two small blocks of carbon, having a cup-shaped hole in each, and a small carbon ball placed inside. The blocks are insulated by parchment or some other non-conductor placed between them. One of these in a case, having a binding screw at each end, forms a very portable microphone. The ball is, in this case, the vibrator, making contact between the carbon blocks. A microphone has been made in this way only $\frac{1}{8}$ in. (cube) in size, being covered with paper, wires being placed against opposite sides. The usual size is $\frac{1}{4}$ in. (cube), either with or without a casing of wood. The speaking microphones mentioned above come nearer to perfection as transmitters than any others, and, unlike others, do not get out of order.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).

The eleventh ordinary general meeting of the shareholders of this Company was held on Monday, the 7th instant, at the City Terminus Hotel, Cannon-street, under the presidency of the Right Hon. W. N. Massey, M.P., vice chairman.

The report of the directors stated, *inter alia*, that the gross receipts for the half year ending 31st December, 1878, have amounted to £140,976 11s. 1d., against £134,753 4s. 10d. for the corresponding period of 1877. The working and other expenses, including a sum of £17,162 for cost of repairs and maintenance of cables, together with interest on debentures and income tax, absorb £71,249 14s. 7d., leaving a balance of £69,726 16s. 6d, as the net profit for the half year, making, with £24,323 3s. brought forward from the previous half year, a total of £94,049 19s. 6d. One interim dividend of 1¼ per cent., amounting to £24,968 15s., has been paid for the half year, and it is now proposed to distribute another of like amount payable on the 15th April, making a total distribution of 5 per cent. for the year 1878. The balance, amounting to £44,112 9s. 6d., has been carried to the reserve fund, which now stands at £75,017 15s. 11d. The Muirhead duplex system was successfully applied to the Madras-Penang cable on the 22nd November last. The Company's cables are at present in good order, and working satisfactorily.

The CHAIRMAN, in opening the proceedings, said: The secretary will read the notice convening the meeting.

Mr. F. E. HESSE (the secretary) having read the notice,

The CHAIRMAN said the secretary will now read the minutes.

The SECRETARY accordingly read the minutes of the meetings of the tenth ordinary meeting, held on November 6th last, of the extraordinary general meeting held immediately afterwards, and of the adjourned extraordinary general meeting, held on December 4th last.

The CHAIRMAN: Is it your pleasure that these minutes be signed? Having signed the minutes, the right hon. gentleman continued: The report, gentlemen, you will, probably, as usual, take as read [hear, hear]. Then, that being the case, in the absence of the chairman—who has gone abroad on business principally connected with telegraphic affairs—it becomes my duty to introduce the report for your approbation by a very few remarks. Gentlemen, it is satisfactory to state that, notwithstanding the bad times upon which we have fallen, and which have so disastrously affected many industries, and ruined some, the affairs of this Company have not been materially affected by these circumstances—in fact, so far from having to tell you, as most people in my position would have to do in opening the accounts of a public company, that we have suffered loss, it is my pleasing duty to say that, upon the working of the half year, the gross revenue has increased by £6,000 as compared with corresponding half year, and the net revenue, by the sum of £2,000. Well, this increase is not very remarkable, and is notable chiefly as showing that telegraphy has become a necessity of trade and commerce, and that, however the ordinary fortunes of trade may fluctuate, yet still the necessity of employing the agency of these companies continues undimished, and that, whether the fortunes of trade are good or bad, it still becomes necessary to maintain a communication through the agency of telegraphy. This is a very remarkable circumstance, because telegraphy may be said to have been established within the memory of men who have hardly yet attained middle age, and the progressive increase in the receipts derived from our business, gradual as it is, is satisfactory, because it shows that the property of this Company is steadily increasing, and is acquiring stability which will place it on a footing with the very best class of commercial enterprise. Gentlemen, I am glad to tell you also that the increase which was established at the close of last year (we are now dealing with the accounts which were closed on December 31st) has been maintained during the three months which have since elapsed. Well, gentlemen, this increase, like most increases of revenue, has partly entailed an increased expenditure. The gross revenue has increased by £6,000 during the half year, and the expenses have increased by £4,039, still leaving a balance in favour of revenue. That increase of expenditure has been principally caused by the necessity of employing an additional repairing vessel at Singapore. When we determined to replace the steam ship Edinburgh by a new ship which we purchased, the Sherard-Osborn, we had hoped that the Edinburgh might immediately be relieved; but it unfortunately happened that several faults appeared at long distances from each other (no less than seventeen having been removed during the half year), and that necessitated the detention of the Edinburgh for a very considerable period, and, of course, entailed an additional expenditure. Well, gentlemen, it so happened (it was so far fortunate, perhaps) that these faults were discovered or revealed themselves just at that time. They have now been set right, and since then we have not heard of any fault. Well, gentleman, that accounts for a portion of the increase in the expenditure. Then it is further accounted for by our having to pay the three years' arrears of patentees' fees on the New Zealand Cable which had accumulated in consequence of the company not being able to arrange with the patentees the amount of the fees to which they were entitled. However, these arrears have now been discharged to the amount of £1,700; and then, in addition to that, there has been the cost of establishing the duplex (of the great advantages of which you are all aware), amounting to £900, and the expenses connected with the duplication of the Australian cable have been about £1,000, so you will see that this increase of £4,000 has been accounted for. I won't venture to say such an expense will not occur again, because our experience of all these companies is that, although you have extraordinary expenses, which you may say will not occur (at least, those particular cases), yet, somehow or other, they seem generally to happen to create this expenditure, and all we can congratulate ourselves upon is that these additional charges we have incurred have been exceeded by the additional receipts. We have proposed the usual dividend for your approbation, and the surplus of our undivided profits will be carried to the reserve fund. I need not, of course, point out to you that in such a business as ours a reserve fund is more necessary, perhaps, than in any class of business, because we are subject to occasional disasters in our property, and we should always make due provision for such occurrences happening; therefore it is that, although our earnings perhaps exceed 5 per cent. on an average, we are not able to divide more than that amount. We think that the proper course—I am speaking of what would be the case if we were to divide close up our divisable profit—but it would be madness to think of dividing in such a property as this all that we earn. We must lay by a very large proportion as an insurance fund to maintain our property in such a state that it will yield a regular annual dividend. The reserve fund has now been increased to £75,000. Well, then, the only other subject which I have to mention is that at Singapore it has hitherto been the practice to store our spare cable with a dock company, to whom we pay a very high rent, and which mode of disposing of our cable is extremely inconvenient on account of the difficulty of communicating with the ship when cable is required. We have now, in substitution of that, decided to establish a hulk at Singapore, which will be alongside the repairing ship, and will facilitate the transmission of cable to the repairing ship without any difficulty and with every possible expedition. From that we expect to make a considerable saving. Well, gentlemen, the only other subject I have to mention to you is that the Australian contract, about which you have heard so much—the contract for the duplication of the cable—has been completed, and negotiations are going forward with the Government to make an arrangement with the Australian Governments by which they shall forego for a period the strict performance of their contract with us, to facilitate the laying of the cable to the Cape of Good Hope, for which the Eastern Telegraph Company have a contract with the Government, and which, you are aware, is a matter of great political exigency. No doubt the public spirit of the Australians will recognise this matter, and will arrange with the Government that a part of the cable made for them should be appropriated for the Cape cable, but that matter is one between the Australian Governments and the Government of this country, and we have nothing to do with it except to say that we shall do all that we can to facilitate the matter. We are, however, under contract with the Australian Governments, and if they think proper to keep us to the strict performance of the contract we must carry it out; but I hope that we shall be able to assist the Government in laying down this Cape cable as expeditiously as possible, the political necessity of which is extremely urgent. Now, gentlemen, with these remarks I have to move "That the report and accounts of the directors now submitted be received and adopted, and that a dividend be now declared of 2s. 6d. per share, making, with interim dividends already paid, a total of 5 per cent. free of income tax for the year, 1878."—Viscount MONCK: I beg leave to second that.

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Mr. NEWTON: Do we run any risk in transferring the cable made for this Company to the Imperial Governments for the Cape cable? You tell us that it is a matter between the Australian Governments and the Imperial Government, but you did not say we should be free from any risk for non-completion of contract. If the cable is not laid by the contract time shall we be in fault? If we run no risk perhaps it is not a matter of much consequence to us, but I think we might have had some advantage from the Government. They give us nothing whatever without exacting very hard terms, and I think you should exact hard terms from them. I want to point out to you that our expenses are considerably increasing instead of diminishing—that our revenue is not increasing in the same proportion. For example, for the half year to December, 1875, we had £109,000 of revenue and £22,889 expenses, exclusive of repairs, and in the past six months we have increased the revenue by £31,000 in round figures, but we have doubled our expenses. The increase in the working expenses is nearly 100 per cent., but the increase in the traffic is 30 per cent. I only mention that, Sir, to show you that the expenses are increasing, and that there ought to be very strenuous efforts made to reduce them, because this property is not returning the dividend it ought to those who have invested their money in it. £5 per cent. is an absurd dividend to the shareholders, especially when you have been only able to add to the reserve on £2,000,000 of capital something like £231,000. Our reserve fund is £231,000 practically, although we have only £75,000 in the balance sheet; £156,000 has been spent for new cable. I also wish to ask whether there is any chance of an amalgamation between this Company and the Eastern Company. I think it is a question which should always be kept in mind by the directors of this Company [hear, hear]. We have so many directors here who are directors on the other that it would be a very simple matter, I should think, between the directors. I shall have something more to say on that subject when the question of the re-election of directors comes on. I should point out to you—which is an omission which should not be—that the reserve fund is stated in the balance sheet at £75,000, but it is not shown on the *contra* side. I think that there have been complaints about this before. I think it should be stated, because with the exception of £28,000 we have practically no reserve. It is used in the business, and therefore it is not what we understand by a reserve fund—it is not what you can make a new cable out of. I think we ought to have the reserve stated on the *contra* side as against the amount stated on the debtor side [hear, hear].

Mr. STURTON: Would this Company benefit by the cable to the Cape?

Sir JAMES ANDERSON: It would benefit by the traffic got from the *South African cables to the East*.

Mr. STURTON: That is very little.

Sir JAMES ANDERSON: It is like anything else—where you carry the telegraph, it grows and spreads.

Mr. CHRISTIE: At the last half-yearly meeting I took occasion to make a remark with respect to the reserve fund and, I am glad to find that it is referred to now, because I said that in the accounts the sum put to reserve was invested in our capital, and consequently I took exception to the whole thing, stating that there was no reserve fund in fact; it might be so on paper. A reserve fund is a thing we should be able to come on in time of need. If invested in our own cable, it seems that we are not receiving benefit of it, as we ought to in the accounts; I was going to make the remark that this £28,000 literally was the only investment, and that the balance of the £75,000 was merely a matter of account. It is not a reserve fund at all. I should like to have that explained, and also I think we ought to have a little further explanation as to handing over the cable we had ready for the Australian Governments to a company which has been formed or is about to be for the Cape [hear, hear]—whether we benefit from any interest whatever in that, because otherwise it appears that we have handed over property and received no benefit at all.

The CHAIRMAN: We have no immediate interest whatever in the Cape cable, or in the Australian cable. There has been no sacrifice whatever of our interests in these arrangements with the Government. I can assure you that these negotiations which have been going on with the Government as to the Cape cable have given us more trouble than we have ever experienced before; and I should be very glad if Mr. Newton would point out some mode by which we could obtain better terms. We have exhausted all the ingenuity we possess, and failed to accomplish the object. We have obtained terms which we think are satisfactory on the whole, or we should not have concluded the contract, and we believe it will be beneficial; and, although it will not possibly make any contribution to the funds of the Company, it will increase telegraphic communication, and it is hardly possible for any company involved in this system to escape some portion of the benefit to be derived from the addition given to telegraphy throughout the system. Well, now, some observations have been made on the reserve fund. It is said that the reserve fund does not exist in the form of cash. That is quite true, it does not, because I must remind the meeting that on a former occasion—at the last meeting—we took powers to raise additional capital, and you were then informed that £100,000 was necessary in order to increase our working capital. When this is recouped we shall reinstate the reserve fund, which will then be available for investment. Mr. Newton says he intends to bring forward a question on the re-election of directors, with which we are extremely familiar, and I suppose we shall have to hear the arguments we are so well acquainted with reiterated on this occasion. If that is the case, I shall have to make some remarks on the subject; but I will not anticipate evil. I will now ask you to agree with the report.

Mr. NEWTON: Will you explain the cause of such a large increase in our expenses since December, 1875? You said that there were three years' arrears of patent fees, £1,700, and the expenses of the duplex, £900—that is only £2,600 out of £20,000. Will you give us an explanation of that?

The CHAIRMAN: There are certain other expenses. There is a very large increase in the expenditure no doubt, and the increase of expenditure must be continuous, because it has been occasioned by the expansion of our system. Since 1875 we have opened several new stations, we have had an additional repairing ship; and, of course, to pay the expenses of those stations, and maintain a repairing ship is rather a costly proceeding; but it has all arisen out of the expansion of the business, and returns to the pockets of the shareholders in the shape of dividend. The policy of expanding our system is a policy which, I think, must commend itself to the good sense of all the shareholders, because it is extremely desirable that we should cover all the ground which requires to be filled, to avoid the intrusion of any rival company. We have been desirous of making this a uniform network of telegraph communication, which shall cover a whole system of communication, and in doing that we have opened new stations, we have been obliged to put down an additional repairing ship, we have been obliged to increase our staff and to incur expenses which must be of a permanent character, and if our system, which now I think has nearly reached completion—but if for any good reason or other we should ask you to consent to its further expansion, these expenses would increase, but so far as we can see at present we have arrived at the expansion of our expenses.

Mr. MARSHALL: When shall we have the Australian cable duplicated, and when are the debentures to be issued?

The CHAIRMAN: As soon as the contract is signed. As I mentioned to you just now, it is possible that there may be some delay in consequence of the temporary agreement between the Government of this country and the Australian Governments, for the purpose of laying the Cape cable; but even supposing that the agreement is carried into effect by the two Governments, it will only cause a very small delay in laying the Australian cable, because only a very small portion of the cable which is now made for the Australian service will be required for the Cape service.

Mr. MARSHALL: May I ask when the duplicate cable to Australia will be completed?

The CHAIRMAN: Eight months from the signing of the contract.

Mr. NEWTON: I am perfectly satisfied with your reply, but still I do not think that we have gathered the fruits of our increased extensions. Our revenue has increased by 30 per cent., and our expenses by 100 per cent., so as yet the extensions have not been profitable. I quite agree that it may be advisable to cover the ground that might be occupied by others, but still these extensions should all be entered into with extreme caution, for I say that they do not produce results commensurate with the outlay of our money.

Mr. NEWMAN: I think, sir, in order that the shareholders may see where the increase or decrease takes place, it would be satisfactory if you could set out in the accounts the outlay of the corresponding half year, the same as the railway companies do, and we should then be able to see what they are.

The CHAIRMAN: We will consult the managing director and accountant on the accounts, and, if that is practicable, it shall be done. You see the Australian Governments have been very wise in duplicating their cable to protect their property, and to make it absolutely impregnable. In so far as we are concerned it is not at all an unprofitable contract for us, because we have a positive subsidy of £32,000 a year, which upon a capital of £600,000 secures you a very fair dividend, even supposing that no profits whatever should arise from the duplication of the cable.—Now, gentlemen, those who are for the report will please hold up their hands. To the contrary. Carried unanimously.

The CHAIRMAN: I now have to move, "That Mr. Pender be re-elected a director of this Company."

Mr. BEVAN: I beg to second that.

The CHAIRMAN: As many as are of that opinion hold up their hands. To the contrary. Carried, with three dissentients.

The CHAIRMAN: The next question is, "That Sir James Anderson, who now retires by rotation, be, and is hereby, re-elected a director."

Mr. WILLIAM MCARTHUR, M.P.: I beg to second that.

The CHAIRMAN put the resolution in the usual way, and declared it carried unanimously.

Mr. MARCUS: The next resolution which I have to move is, "That Mr. John Ball and Mr. Henry Dever be, and they are hereby, appointed auditors of the Company for the ensuing year at a remuneration of £50 each."

Mr. AGNEW: I have much pleasure in seconding that.

The CHAIRMAN: The question is, that Mr. John Ball and Mr. Henry Dever be, and they are hereby appointed, auditors of the Company for the ensuing year, at a remuneration of £50 each. Those in favour of that please hold up their hands. To the contrary. Carried unanimously. That, gentleman, concludes the business of the meeting.

Mr. CHRISTIE: I beg to move a vote of thanks to you, sir, for being in the chair.

Mr. NEWTON: I beg to second that.

The CHAIRMAN: I am much obliged to you for your kind vote.

The meeting then separated.

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).

An extraordinary general meeting of the shareholders in this undertaking was held on Tuesday, the 8th of April, at the City Terminus Hotel, Cannon-street, under the presidency of Viscount Monck, the chairman of the Company, "for the purpose of receiving a report from the directors as to the formation of a French company for the working of the Company's Brest, St. Pierre, and Duxbury cable, and considering, and, if thought fit, approving the proposals of the directors, and passing such resolutions in relation thereto as the meeting shall determine."

The CHAIRMAN, in opening the proceedings, reminded them that at the last meeting the fact that a competitive company was being started in France was alluded to, but the shareholders showed their confidence in the directors by not discussing the question at the meeting, as he told them that, in his opinion, such a discussion at that moment was unadvisable in the Company's interests. They were called together to-day for the single purpose of arming the directors with the powers which they conceived to be necessary for meeting the opposition which was only threatened when they last met, but which now they had reason to believe had assumed a more definite form. The notion of getting up a company in France to compete with our companies in England was one which had been brought forward on several former occasions. For the last two or three years they had frequently heard of the intention of instituting such a company, and these rumours were always connected with the name of M. Pouyer Quertier, a man of great eminence, whose reputation was well known, but which, he could not conceive, was earned principally as the Finance Minister of the French Republic under M. Thiers. The enterprise, he believed they would agree with him, after he had furnished them with a few facts, savoured, to say the least of it, of an

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adventurous, if not a reckless spirit. They might say that there were three parties interested in a scheme of this sort—the public, the possible shareholders, and a class of gentlemen whom he would call promoters, financiers, and constructors. With respect to the public, their interest was solely in having the traffic—their communications by these lines—well and effectively performed. It was not intended for a moment that this competing line of telegraph was to subserve any great public want or to improve the telegraphic communications between Europe and America. There were no complaints whatever as to the manner in which the messages were forwarded, and when he mentioned to them that the average time taken to transmit a message from Paris to New York was under twenty minutes, he did not think that if any complaints were made they would treat them as worth being listened to for a moment. They were told that it was offensive to the susceptibilities of the French people—to their national *amour propre*—that their telegraphic communications should be in the hands of foreigners. He wished to speak with the utmost respect of such a feeling, but he thought it must be a most powerful, not to say extravagant passion, if it would induce a set of men to embark capital in an undertaking which the clearest *data* showed would yield them no return, and an enterprise the first result of which would be that they would lose fifty per cent. merely for the benefit of a sentiment of this description. As to the possible shareholders, the second class interested in such a scheme, it had been laid down by authority that, given any number of telegraph lines of equal efficiency and working under similar circumstances, each cable would obtain an equal amount of the traffic—that was to say, if there were six cables, each would get a sixth. He did not say that this was invariably the case, but he believed that it was a very fair test to apply when they were discussing a question of this kind. When, therefore, M. Pouyer Quertier's two cables were down—for he ought to have said that that gentleman proposed to put down two cables—there would then be in existence six cables—these two, one belonging to the Direct United States Cable Company, and three belonging to this Company, and, consequently, according to the formula and law laid down, the proportion of the traffic which M. Pouyer Quertier's company ought to obtain would be one-third. That, however, was assuming that all things were equal; but he wished to call attention to the fact that this Company and its colleague, the Direct Company, had by special agreements the right to bring almost every message that crossed the Atlantic from America here, and they had priority in, he believed, all European countries over any other telegraph company that might exist—that was to say, the Governments of all European countries, and even of France, were bound to send all messages committed to them by these companies' lines unless the sender directed to the contrary. This must give them an immense advantage over any other company which had not a similar priority secured to it. Did any reasonable man think that eight per cent. was a fair allowance to make for these enormous advantages? Yet even this allowance would reduce M. Pouyer Quertier's proportion from one-third, or thirty-three per cent., to twenty-five per cent. In his prospectus M. Pouyer Quertier had coolly stated that he expected to get 48 per cent., but this was a process of reasoning which he (the chairman) could not comprehend, because M. Pouyer Quertier assumed it on the ground that the old French company obtained 48 per cent. with its two cables; but that was when there were only two other cables in existence, and when the two companies divided all the traffic between them, but the introduction of a new participator had changed all this. M. Pouyer Quertier had, however, dropped down to 40 per cent., but he (the chairman) asserted that he would get no more than 25 per cent. of the traffic, or £178,750. The working expenses, assuming them for the two cables to be one-third more than those of the Direct Company, which worked only one cable, would be £67,000; the provision for a reserve fund, taking it to be in proportion to that allowed by the Anglo and the Direct Companies, would be about £100,000; and M. Pouyer Quertier's own estimate for the redemption of his bonds was £32,000, making a total of £199,000 or £11,000 more than he would receive on his share of the traffic. He would also take, as a means of testing the value of M. Pouyer Quertier's prospectus, the price which the shares were like to realise in the market. If the estimate he had just given were anything like correct, it was, of course, unnecessary for him to go into this question, but taking M. Pouyer Quertier's estimate, could any man of common sense conceive that a third participator in the same revenue—because there was no pretence that the gross revenue of trans-Atlantic telegraphy would be increased by this operation—would be better off in the market than the Anglo, and the Direct Companies? Now, as to the market value of the shares of these companies, he regretted to say that they commanded the same proportional price in the market, and they all knew to their sorrow, as he did, that that price had a depreciation of about 40 per cent [a voice: 45]. Well, he did not wish to overstate the case, but would M. Pouyer Quertier's company do better? He had, therefore, come to the conclusion that whether they measured the chances of this company by its proportion of revenue, or by the probable price which its shares would bring in the market, there was nothing before those who might be induced to subscribe to it but utter ruin as far as their subscriptions were concerned. This French company, therefore, could not, they would conclude from what they had said, do much good for itself, but it might do this Company much harm; but before he came to that matter he should like to say a few words about the third class interested in such a scheme as this—the promoters, financiers, constructors, and so forth. They were a valuable class as a whole; a great number of the most important improvements which had taken place in our social and domestic condition within the last few years—railways, gas, telegraphs, &c.—were in a great measure due to that class which, however, although a valuable was not an invaluable class, and their operations ought to be closely scrutinized by those who became shareholders in the undertakings they brought out. He admitted readily that in the prospectus and the different publications brought forward by M. Pouyer Quertier and his friends, a graceful haze was thrown over the whole thing as regarded where the money was going, but he (the Chairman) shrewdly suspected that a great deal would go into the pockets of men who would not give any great value for it. When they found this scheme taking a more definite shape they took measures to protect the shareholders' interests. They sent over to Paris, and they offered terms, which, without being very onerous to the company, would have brought these proposals within the limits of the public requirements—that was to say, would have postponed the laying of any cable until the present French cable had been proved inefficient. Those terms, however, led to nothing, and they must now meet the question boldly. They came there that day to ask shareholders to arm the directors with such powers as would enable them to undertake the war effectively on the shareholders' behalf. The Direct Company was entirely with them in this matter. The report of the directors and the memorandum annexed to it would have revealed to them the shape they proposed to take in order to meet the French company. If the company referred to in the memorandum should be constituted, it would work in harmony with this Company, and there would be no change of traffic, and no important alteration in the management of the business without the concurrence both of the Company and of the Direct Company. The proposal was a war measure on the part of this Company, and they proposed it to the French as a cheaper method of satisfying their *amour propre* than investing a couple of millions of money in an undertaking which could never pay them anything. In conclusion, he moved the following resolution:—"That the Board of Directors be, and they are hereby, authorised to make, execute, and carry into effect any contract or contracts, or other deeds or documents, and do all other things which they may deem requisite or desirable for giving effect to the project set forth in the printed report of the directors to the proprietors, dated the 31st of March, 1879, and the memorandum annexed thereto, respectively submitted to this meeting, and either upon the terms stated in such report and memorandum, or with such modifications, if any, as the Board may approve; and, for the purpose of the said project, and the protection of the Company's interests in France, to pay, apply, and invest any moneys of the Company as the Board may from time to time think fit."

Sir DANIEL GOOCH, Bart., M.P., a director, formally seconded the motion, and it was at once carried unanimously, without discussion.

Mr. W. FORD then proposed and Mr. VEARS seconded a vote of thanks to the chairman, Mr. Vears observing that he had never attended such a wonderfully quiescent, or unanimous meeting.

The resolution was carried, and the meeting then separated.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.

The following is the report submitted by the directors to the second ordinary meeting of this Company, held on Thursday, the 10th day of April. The directors submit the annexed accounts of the Company for the year ending December 31, 1878, showing the gross revenue to be £26,310 16s. 2d., and the expenditure £14.732 6s. 11d., leaving a balance of £11,578 9s. 3d. Of this amount £10,996 11s. 7d. is absorbed by payment of the debenture interest, and the directors propose to carry forward the balance, amounting to £581 17s. 8d., together with the balance brought forward from the old Company, amounting to £1.250 2s. 9d. The working expenses of the stations abroad and the expenses incurred in London are £8,481 6s. 7d. This is considerably less than was originally anticipated, but still the staff is sufficient to a manage a much greater amount of traffic than the Company has yet been favoured with. The item of £3.962 17s. 3d., for working expenses of the repairing steamer covers all outlay from the day she was handed over to the Company by the builders in London, and includes the cost of sending her out to the West coast. The expense of maintaining the cables and land lines, amounting to £1,645 1s. 5d., has been incurred, in the first place, in temporary repairs of the damage arising from earthquakes, and latterly in the permanent repairs effected by the Company's repairing steamer since her arrival on the West Coast in October last. The directors have charged to revenue the expense of the formation of the new Company, amounting to £532 8s., and have written off the cost of the furniture for the London office, amounting to £94 17s. 3d. The considerable outlay involved in keeping a cable-repairing steamer was well considered by the directors before deciding on the steamer being contracted for; and, in order to utilise the vessel when not employed in cable work, they had her so constructed as to be adapted for carrying water between the ports on the West Coast of South America, and other purposes.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices April 9.		Business Done Week Ending April 9. Highest.		Lowest.	
Anglo-American	55¼,	6	57⅛		55⅜	
Do. "B"	85⅛,	6¼	86¼		85⅛	
Do. "A"	26⅛,	7	29		26⅛	
Brazilian	6 11-16,	13-16	6⅞		6 11-16	
Cuba	8,	¼	8 5-16		8¼	
Do. Ten per Cent. Preference	15⅛,	⅜	—		—	
Direct Spanish	1⅛,	2	—		—	
Do. Ten per Cent. Preference	10⅛,	11	10⅜		10⅜	
Direct United States	10⅛,	11	11⅛		10⅛	
Eastern	7⅛,	⅛	7⅞		7⅛	
Do. Six per Cent. Debenture	105,	8	—		—	
Do. Five per Cent. do.	100,	3	100⅛		100⅛	
Do. Six per Cent. Preference	11⅜,	⅜	11⅜		11⅜	
Eastern Extension	7⅛,	⅛	7⅛		7⅛	
Do. Six per Cent. Debenture	103,	9	—		—	
German Union	7⅜,	8⅛	—		—	
Globe Telegraph and Trust	4⅛,	5	6		4 15-16	
Do. Six per Cent. Preference	10⅛,	⅜	10⅜		10⅛	
Great Northern	8⅛,	⅜	8⅛		8⅛	
Indo-European	21,	2	—		—	
Mediterranean Extension	2⅛,	3⅛	2⅜		2⅜	
Do. Eight per Cent. Preference	9⅛,	⅜	9⅛		9⅛	
Reuter's	9⅛,	10⅛	10		10	
Submarine	215,	25	222		221	
West India and Panama	1⅝,	⅜	1⅞		1⅞	
Do. Six per Cent. Preference	8⅛,	⅛	8 9-16		8⅛	
Western and Brazilian	3⅛,	4⅛	4 3-16		4	
West. Union Seven per Cent. 1st Mort.	114,	18	—		—	
Do. Six per Cent. Sterling	101,	3	102⅛		102⅛	

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NOTES.

THE ELECTRIC LIGHT AND THE "EDINBURGH REVIEW."—We believe that the article on the electric light in the current number of the *Edinburgh Review* is from the pen of Dr. Mann.

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY.—In the report of the meeting of this company given in our issue of April 5, it should read, "their Malta agent was at Rome, &c.," instead of "their Corfu agent."

ROYAL ENGINEER TELEGRAPH CORPS.—Major Webber, R.E., divisional engineer for the South Eastern District of the Postal Telegraphs, has, at very short notice, followed the Corps of Military Telegraphers, whose departure for South Africa we recently announced. Captain Turner is left in charge of Major Webber's district.

POTENTIAL.—In a letter on this subject Sir W. Thomson says: "Mr. Baynes might be referred to 'Papers on Electrostatics and Magnetism,' secs. 327—340, for definitions of potential, electromotive force, electric force, &c., not open to the objections brought by Mr. Baynes to some other statements. . . ." Dr. Hopkinson writes: "Mr. Sprague is entirely wrong in supposing that electrostatics and electrodynamics are two distinct universes to the mathematician, or that electrostatic potential may not turn up in electrodynamical problems." Next week we shall be able to lay before our readers the views of Prof. J. Clerk Maxwell on some of the questions in connection with this subject.

THE SOCIETY OF TELEGRAPH ENGINEERS.—We understand that Mr. Latimer Clark has addressed the President and Council of this Society, recommending a wider scope for its proceedings so as to include those of an *Electrical Society*. Until we know more about the proposal, and the action likely to be taken by the Council, we refrain from comments. But it is evident from this, as well as from numerous letters we have received on the subject, that our recent article drawing attention to the want of an Electrical Society has met with much favour. Whether the Society of Telegraph Engineers would be able to supply what is needed is another matter. A radical alteration in its title would obviously be necessary.

EXPERIMENTAL DETERMINATIONS OF SIGNALLING SPEED.—The experiments made by Hughes showed that the time required with his apparatus to produce a signal through different lengths of a submarine cable having a copper conductor 0.064 inches in diameter (No. 16 B.W.G.) and an insulating coat 0.069 inches in thickness were as follows:—75 miles, 0.025 seconds; 150 miles, 0.045 seconds; 225 miles, 0.080 seconds; 300 miles, 0.115 seconds; 375 miles, 0.140 seconds; 450 miles, 0.160 seconds. Whitehouse found by a series of experiments on the Atlantic cable of 1858, having a conductor composed of a strand of seven copper wires, each 0.028 inches in diameter, and having three coats of gutta percha of an aggregate thickness of 0.148 inches, that the time required to produce a signal upon an ordinary relay was as follows:—145 miles, 0.14 seconds; 247 miles, 0.34 seconds; 494 miles, 0.79 seconds.

AUTOMATIC REPEATERS.—Mr. C. S. Bulkley, when Superintendent of the Washington and New Orleans line, invented, says James R. Reid, the earliest of the automatic repeating instruments, which now form so valuable a part of American telegraphic machinery, and which enabled messages to be sent direct from New York and Washington to New Orleans. It is thus described by F. L. Pope. Bulkley arranged the terminal main batteries upon each circuit, so that when the line was at rest the action of each battery opposed and neutralised that of the other. The signals were sent by an ingenious transmitter, worked by a local circuit and key. The transmitter reversed the poles of the battery at the sending station every time the key was depressed. It was the precise arrangement now forming an important portion of the quadruplex apparatus. The relay, thus brought into action at the distant station, worked by a local circuit another transmitter for the next circuit. Of course it would operate equally well in either direction, as it mattered not which battery was reversed to bring it into harmony with the other.

THE TELEPHONE WITHOUT A DIAPHRAGM.—Some experiments bearing on the origin of the sounds produced in the telephone (a point much disputed lately) have been made by M. Ader, who says he has not only been able to make a telephone speak without a diaphragm, but to make it speak louder and with less alteration of the voice than in the ordinary telephone. He reduces the dimensions of the magnetic core to those of a simple iron wire 1mm. diameter; one end of which is fixed to a wooden board. A small coil of fine wire is added, and a microphone speaker is employed. Putting the board to the ear, speech is heard distinctly, but the sound is greatly increased if a metallic mass be applied to the free end of the iron wire; one can then hear at 10 to 15ctm. If the iron wire be in contact at both ends with metallic masses, a better effect is obtained, but the two masses must not communicate with each other metallically. M. Ader also finds speech reproduced from a simple bobbin, without magnetic core; but the windings of the wire must be very loose, not pressed together. If they have been dipped in gum-lac no sound is heard, unless an iron wire or magnetic needle be placed in the bobbin, or a helix interposed in the circuit of the first, the ends of these organs being attached to the board on which the bobbin is fixed. M. Ader is led to agree with M. Du Moncel that the sounds produced by a magnetic core are probably the consequence of shortenings and lengthenings of the magnetic rod, through rapid magnetisations and demagnetisations.

THE DETECTION OF TORPEDO BOATS.—*The Times* of the 15th April contains a paragraph which we as yet cannot understand. It speaks of two lights from one machine as a wonderful discovery, and altogether the writer seems to have gone completely out of his depth. "An important discovery," says the writer, "has been made at Portsmouth in the use of the electric light as applied to our ships of war for conning the waters around them and thus enabling attacking torpedo boats to be detected and assailed. Up to quite recently one light only could be produced at the same time by one engine and one machine, but on experimenting with Mr. Henry Wilde's patent electro-magnetic induction machine it was found that a couple of lights could be produced from a machine by simply connecting the two projectors; or, in other words, by producing continuous currents by joining the two lights with the generator. That this improvement is of great importance will be readily understood when it is borne in mind that the cost of generating a powerful light on board ship—amounting to about £1,300 even when steam is supplied from the ship's own boilers—has restricted the use of the machine

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to the production of a single light. This was to deprive the electric light of a great part of its practical value as a torpedo detector, as a wary enemy might find it quite possible to come to almost close quarters without being discovered. The range commanded by one light is generally not much more than half the horizon. Now, however, at a trifling increase of first cost a complete and efficient arrangement can be obtained. This important result has been brought about by means of experiments made while considering the best fittings to be given the double turret-ship Devastation, now completing for sea at Portsmouth; but the same improvements will, doubtless, be introduced into the electric apparatus of the Iris, Dreadnought, Neptune, and other war ships."

Electric Lighting at the Albert Hall.—The Council of the Royal Albert Hall have decided upon offering special facilities by which the leading scientific principles upon which the subject of electric lighting is based, as well as the distinctive differences of some of the methods which have been devised for its practical application, may be more extensively made known. These facilities are to be presented in the form of a general exhibition of the various machines, lamps, and other apparatus connected with the subject, to be accompanied, at its opening, by a lecture illustrative of the general principles of the subject as well as of the particular systems of lighting under exhibition. To render the application of these scientific principles clearer and more effective, it has been arranged that, in addition to the specimens placed for mere exhibition in the arena of the hall, the various electric lights shall also be shown here; while the machines producing them, and driven, some by steam and some by gas engines, shall be arranged contiguous to the hall, and, where convenient, so as to be readily accessible. Still further to exemplify the sequence of operations connected with the production of the electric light, a complete apparatus, together with its motive power, will be periodically placed in operation in the arena of the hall. His Royal Highness the Prince of Wales, President of the Royal Albert Hall Corporation, has signified his intention of being present at the inaugural lecture, which will be delivered by Mr. W. H. Preece, M. Inst. C.E., Electrician to Her Majesty's Post Office. Already the Siemens, Gramme, Lontin, Wilde, Jablochkoff, Rapieff, Wallace-Farmer, and other systems are promised for exhibition. It has been arranged that the inaugural lecture shall be held on the evening of Wednesday, the 7th of May, and that the exhibition shall remain open until the end of the week. In order to render the exhibition as complete as possible, and historically illustrative of the entire subject of electric lighting, the Council of the Albert Hall request the co-operation of all those who are in possession of objects, whether of past or of present interest, in direct connection with the subject, and they invite them to communicate thereon with the manager of the hall.

The American Rapid Telegraph Company.—According to the *New York Herald*, a company, under the above title, was organised about a month ago for the purpose of bringing into use an "Electro-mechanical" telegraph instrument, capable of transmitting "at least 1,000 words per minute," and also for the introduction on overland lines of a wire of cast steel, coated with copper "by the electric process." Mr. Edwin Reed, of Maine, is the president; Mr. Th. Wallace, of Connecticut, the vice-president; and Mr. L. S. Hapford, of Boston, the treasurer. They state that they have a capital of 3,000,000 dollars, and they intend to commence immediately the erection of lines between Boston and Washington, taking in New York, and between the last-mentioned city and Chicago. The instrument, it is said, looks like a combination of a small piano and a sewing machine. Twenty-eight keys correspond to the letters of the alphabet and needed stops, and a treadle causes the tape to move, its speed being regulated by attachments to the keys. A simple device also provides for the rewinding of the tape for the sending machine. The system adopted was described by Mr. Reed as follows:—"When a message comes to us the first thing we do is to record it on a paper tape by punching shall holes, which are arranged to correspond with the dots and dashes of the Morse system. Along one edge of the tape run the positive impressions and along the other the negative. We have a machine for doing this punching work, and I would draw attention to the peculiarity that it spaces the various letters according to their length. The letter 'E' is represented by one dot, therefore the tape is fed out only a little way; 'H' takes five dots, therefore a longer piece of tape is allowed to run out when it is to be printed, and so all difficulty in reading is obviated. Mr. Reed added that this punching could be done at the rate of 2,000 words an hour, and said that the company intended to send machines out to the offices of all persons who have much telegraphic correspondence, so that the punching might be done there by clerks or type writers. 'Then,' he said, the 'tapes could be sent to the office of the company instead of manuscript. 'The company will,' he said, 'have a large number of these machines, so that when long messages come in they can be divided up and punched in a very few minutes. As to the actual telegraphing of the despatch that can be done at the rate of at least one thousand words a minute,' said Mr. Reed. The prepared tape is put in another machine, wherein it passes over a metallic cylinder. Two needle points press on it, which are connected with the poles of a galvanic battery. That which leads from the negative pole is placed over the negative row of holes in the tape; the other, connected with the positive pole, runs over the positive row of holes. The metal cylinder is connected by a wire with a needle point at any distance off, which in turn presses on another tape—the receiving one—likewise running over a cylinder. Side by side with this point is another, the wire of which runs into the ground, as does also one of the wires of the double battery which is used to provide the current. Now, suppose the first cylinder to be revolved, you will see that every time a hole in the tape comes under either of the points the point touches the metal cylinder and a current is excited, running either way, according as the hole is under the positive or negative pole. As this current strikes the receiving tape, it decomposes certain salts of iron with which it is impregnated, and prints dots and dashes, according as the holes run in the original tape. Now, as the positive and negative impressions are arranged apart, side by side, there is no fear of the impressions running into one unbroken line, and so the rapidity with which the despatch can be forwarded is only limited by the speed with which the first cylinder is revolved. The chemical tape is finally placed in the hands of copyists, who can render it into manuscript at a rate of 1,500 words an hour. Some compositors would rather read from it than from writing, and in the case of long despatches the company will provide for their rapid completion by dividing them among several hands." Bearing in mind the porous character of electro-deposited copper, we fear that the new compound wire will be even less durable than the combinations of copper and iron or steel which have hitherto been tested.

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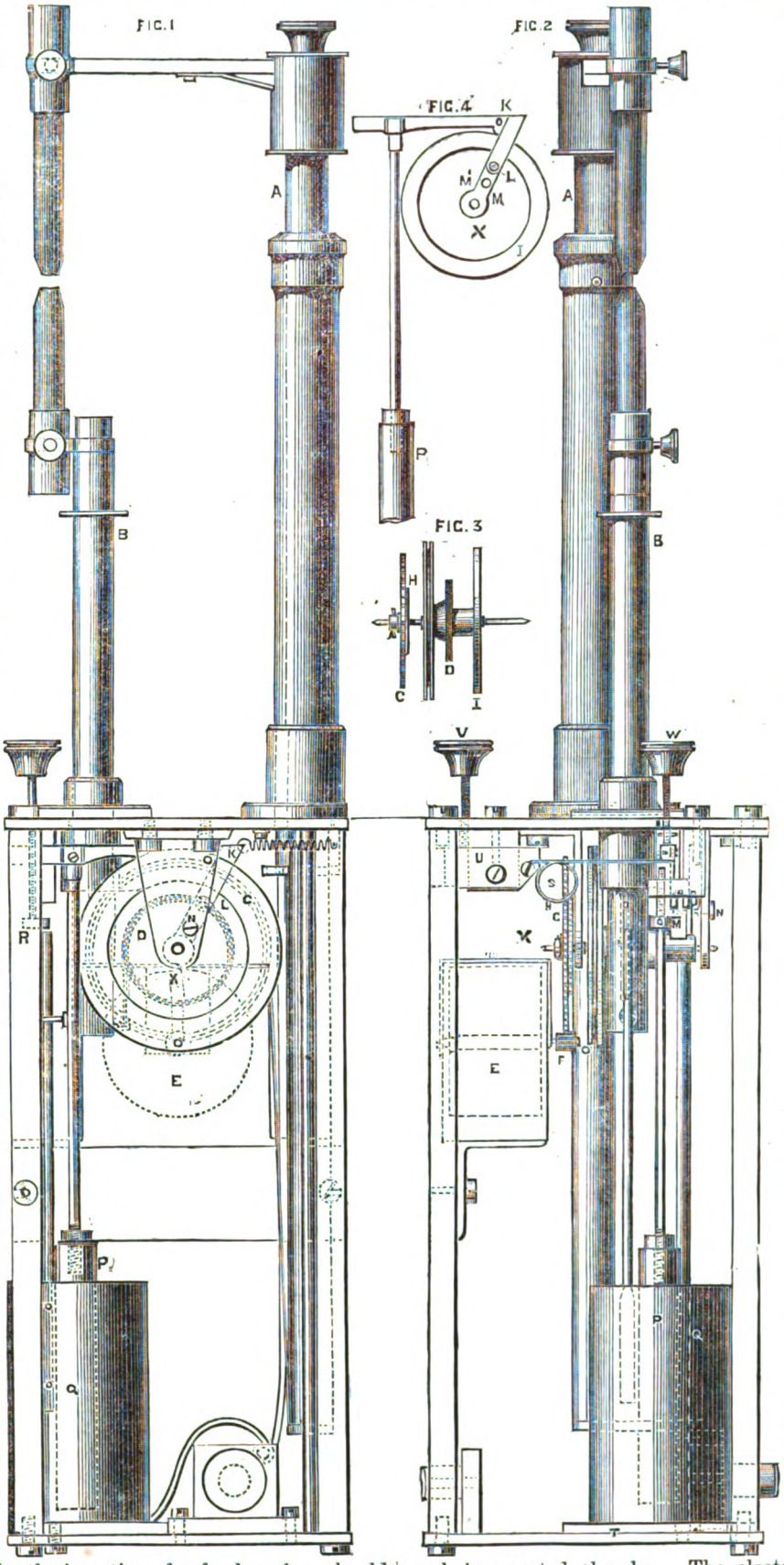
THE KRUPP ELECTRIC LAMP.

Herr von Krupp, of Essen, has recently patented an invention for "improvements in electric light apparatus." The main object of the invention is to regulate automatically the position of the carbons of an electric lamp, "in a simpler manner than heretofore, without abandoning the generally acknowledged conditions on which the precision of motion of the single parts depends." The invention includes the application of a brake appliance for the automatic regulation of the distance between the two carbon points. A fan or fly revolves in quicksilver, or other liquid, for the purpose of regulating the motion of the carbon holder, this part of the apparatus being designed as a substitute for clockwork. A magnetic coil with iron casing and iron bottom is employed in connection with the motion of the brake appliance. Fig. 1 is a side elevation, and Fig. 2 a front elevation of the lamp, in which A is the holder for the upper positive carbon, and B the holder for the lower negative carbon. The upper holder A is suspended from the disc or pulley C by means of a jointed chain or wire, the lower holder B being similarly attached to a disc or pulley D, the latter disc being just half the size of the former. The chains or wires are so passed round the pulleys that when the holder A descends a certain distance by its weight the other holder B ascends to half the distance. Accordingly the electric arc formed between the carbon points occupies a fixed position. As the weight of the upper holder A must not be too small, because its motion would then be easily influenced by dust and dirt, it is necessary to have an appliance for retarding and regulating its course or travel. For this purpose a fly or fan E is applied, which revolves in mercury or other liquid. On the spindle of this fly there is a pinion F, which gears with a tooth wheel G on the spindle X of the chain pulleys C and D. In order that the fly E by the insertion of a fresh carbon should not have to revolve backwards, the tooth wheel G is fitted with a pawl wheel H.



The setting and regulating of the proper distance between the carbon points is effected in the following manner:—On the same spindle X as the pulleys C and D and tooth wheel G there is a disc I, as shown in the separate view, Fig. 3. Fig. 4 is a separate view of a brake of a peculiar form acting on this disc I. The brake consists of two parts, K and M, which are jointed together at L. The lower part M can turn on the spindle X, and has a hole M^1, in which is inserted a small peg N, Figs. 1 and 2. The peg N has much play in the hole, and the backward motion of the brake is limited thereby. O is a brake block on the upper part K of the brake, P is the keeper for an electro-magnetic coil Q. This keeper is by a brass rod suspended from the other end of the part K.

When the lamp is in action, the keeper P is drawn into the coil Q, whereby the brake-block O is pressed against the disc I, turning the latter in its further movement downwards, that is, so far as the set screw R, Fig. I, will allow. Thus, the upper carbon point will be raised, and the lower carbon point lowered, and the electric arc then makes its appearance. The carbon points now gradually consume away, the current becomes weaker, and its effect on the electro-magnet Q is lessened. The brake K supported by the spring S—the action of which can be suitably regulated in proportion to the strength of the current by means of the lever U, and set screw V—and by the weight of the carbon holder, moves slowly back. The brake disc I is thereby enabled to turn forward, and the carbon points can approach each other. When this movement has proceeded as far as the brake disc I moved back before, then the lower part of the brake comes to bear against the peg N. By the further weakening of the current the brake will now turn its joint at L, the brake block O releases the disc I, and the carbon points move towards each other, whereby the current is strengthened and the brake is again applied to the disc I, either simply to hold it when the carbon points are in their right position or to pull it back when the carbon points are too close together. When inserting new carbons the brake is fixed by the set screw W, and the work is arrested thereby. The electro-magnetic coil Q rests on the bed-plate, T, of the lamp, and is surrounded by an iron casing, whereby its power of attraction for the keeper is increased.

The fixed position of the arc provides for keeping the light in

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the centre of a concave reflector. Where this is not required the lamp may be simplified by leaving out the moving parts for the lower carbon holder, making it fixed instead of movable. The lamp thus devised has been employed by Herr von Krupp in portions of his great factory at Essen, in Germany, and the results have been so satisfactory that the light is being extended to other parts of the establishment.—The *Engineer*.

SOUTH AFRICAN TELEGRAPHS.*

(CONCLUDED FROM PAGE 245.)

As insulators for the wire the Andrew's porcelain, and Oppenheim—Australian pattern—are to be preferred to the iron-hooded form, where damage, either from wilful or accidental injury, is not to be apprehended. The double-shed brown earthenware insulators, adopted between Maritzburg and Durban, are an absolute failure. Their insulating capacity is good enough, excepting at times of dense fog, when their insulation becomes weak. They are also mechanically up to their work. But they are singularly open to injury from lightning. A storm rarely passes over a line where they are, without smashing from three to ten. A heavy charge enters the wire, and passes round the binder, and the condition of a charged Leyden jar is then produced, in which the wire and binder become the representative of the inner coating, and the bolts of the insulators, which, with iron posts, are in connection with the earth, take the place of the outer one. The section of the earthenware in such circumstances, fails to prevent a disruptive discharge, the insulator is destroyed, and the wire brought to earth. At the point where the discharge takes place a small globule of metal is raised on the wire, and a black discolouration is caused on the earthenware. The mechanical structure of the brown earthenware seems to provide a line of passage at that point. Along this route, portions of the line, furnished with Siemens iron-hood insulators, have given one injured in five months, whilst 50 per cent. of the brown earthenware have been destroyed within 18 months. All the poles are, of course, furnished with lightning protectors. In one place, where the line crosses the Stormberg Mountains, between Dordrecht and James Town, even the iron-hooded insulators on wooden poles, are, however, frequently damaged.

The Andrews insulator seems to leave little to be desired, except, perhaps, a trifling improvement in cutting short the porcelain covering of the stalk. One great excellence in the Oppenheim insulator is the absence of cement for fixing the pin to the cup. The attachment is made by a screw, and on this account the iron and porcelain parts can be packed separately for transport, which is a valuable provision in traversing a rough country, and also a great convenience in effecting repairs. It is a good procedure to substitute a wooden pin for the iron one in these insulators wherever lightning is especially troublesome. The wooden pin also gives increased immunity from fracture of the porcelain under the influence of great vicissitudes of temperature. The coefficients of expansion in porcelain and iron are much more widely severed than they are in porcelain and wood.

The iron-hooded insulator should, as a general rule, be had recourse to where damage from accidental mechanical causes is liable to occur, and then the Indian pattern, with the wire bound to each insulator, is to be preferred to the plan sometimes adopted of suspension from a hook, with a strainer at every seventh pole. In all other situations the Oppenheim insulator, with a wooden pin substituted for the iron ore, should be used.

The roads in South Africa are, in many places, merely waggon tracks drawn across the Veldt, and as one track becomes cut up, or heavy, another is opened, until, in some instances, the road grows to 100 yards in width. Hence the ordinary rule of bringing the last pole near a crossing, up as nearly as possible to each side of the track, becomes inapplicable. In such situations trenches are generally dug, with a radius of six feet, round each pole, and filled with stones. Waggons, nevertheless, still run up against the poles, especially at night. A wooden pole has an unmistakable advantage over iron; it stands a much less risk of being smashed in a collision. With a sneezewood pole the waggon often comes off second best from a conflict, and it is therefore treated by transport riders with a larger measure of respect. Between Komgha and Butterworth, a distance of twenty-six miles in the Transkei, where there are iron poles, seven interruptions of the circuit have occurred from this cause, since the opening of the line in September last; whilst no stoppage at all from the same cause has occurred between Butterworth and Maritzburg, where the poles are of sneezewood.

When more wires than one are carried along upon the posts contacts between them are very apt to be set up on road-crossings by the "vorschlaght," or thong, at the end of the long whips being swung round them whilst flogging the oxen. Road-crossings most commonly occur at some rising ground where the lash has to be vigorously applied to his team by the driver. To meet this cause of injury poles are placed as close as possible at such spots, and straining insulators used, with the wire stretched as tensely as possible. Sometimes each wire is run 30 or 40 yards away from its neighbour on a separate line of poles, and the two wires are only brought nearer together when the line is beyond the reach of the vorslacht. Such, however, proves to be only a sorry shift. A better expedient is to employ double poles with six-feet arms, carrying one wire at each end. The line wire is then shackled off, or double bound and soldered at each side to an invert, and light steel No. 12 wire is used for the absolute crossing.

When straining insulators are used, the wedge form is the best; but great care is necessary in driving the wedge home so as not to nick the wire. If nicked the wire will break there at the first frost, and at long spans there is even danger of the wire getting worn through by friction against the edges of the wedges. The eccentric form of insulator can only be depended on along very flat ground. If the ground is much broken, the nut refuses to take a proper grip, and the wire slips under the slightest applications of force. Even variations of temperature are sufficient to draw the wire away from the eccentrics. In broken country not one eccentric in ten stands properly to its work after having been in use a couple of years. Some portion of this imperfection is due to careless workmanship in straining. But that cannot be obviated, because the telegraph engineers in rough countries rarely get the chance of choosing their skilled workmen.

Black iron coach screws are better than galvanised iron screws for fixing iron-hooded insulators or iron brackets to the poles. Galvanised iron screws are very liable to break off, in consequence of the brittleness communicated to them in the operation of galvanising.

Upon the whole, there is a remarkable and even surprising immunity from damage by lightning with the telegraph lines in South Africa, which would hardly have been looked for where thunderstorms are so frequent and so severe. The explanation of this most probably is the sparseness of the lines and the limited number of the wires. The areas concerned in the thunderstorms are very large, and, in regard to them, the tracks of the telegraph lines of great relative minuteness.

Every pole in the South African system of telegraphs has its lightning-protector, made of the same gauge as the line-wire, and sharpened at the point, which is raised two inches at most above the top of the pole. Not very long ago a *fiat* was issued in South Africa that all lightning-protectors were to be done away with, because they were more trouble than they were worth. The protectors, however, which earned this proscription for themselves simply sinned in being unnecessarily long. A notion prevailed that they must extend eighteen inches above the pole to be of any use, and they were then liable to be driven into contact with the line-wires by the roosting of birds, and by other disturbing agencies, and so to cause full earth. These difficulties are, however, all obviated by the simple expedient of docking them of their redundant length. The lightning-protectors are also liable to become troublesome from loose staples. When only one wire is suspended from the poles a very good plan is to wind the lightning-protector spirally round the post. A very excellent proceeding, also, is to bore a hole some distance through the top of the pole, and thread the wire of the protector through it. Two staples are then used at the top of the pole, and other staples fixed six inches apart for three feet down, and twelve inches apart afterwards.

Thousands of dry, imperfectly soldered joints have had to be cut away from the South African lines within the last eighteen months. More careful joining is now universally insisted upon. The Fletcher's soldering apparatus, with a 24-inch handle, with cotton waste steeped in paraffin as fuel, is in use, and proves of inexpressible value. For leading in wires, gutta-percha is of no use; it becomes worse than good-for-nothing in a few months. The Hooper's compound employed by the Telegraph Department of India is the best insulating covering for wires that has hitherto been adopted.

In dry tracts of country the greatest imaginable difficulty is found in making earths. Along the dry, and often absolutely rainless karoo, the wires have to be carried to the river beds, or rather to the sandy gullies, where there would be river beds if there were any water, and earth-plates have to be buried in these. Occasionally Steinhilt's historical method of making a rail serve the purpose of a second wire is turned to account. Where this cannot be done, a pipe is often carried to the earth-plate, and water poured into it by one of the officers or attendants every morning.

* By J. Sivewright, General Manager of Telegraphs in South Africa. Communicated by Robert James Mann, M.D., to the Society of Arts.

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My conviction of the practicability of carrying a line of telegraph overland through the interior of Africa is already on record. The experience which has been gleaned during the last nine months in travelling through the country from King William's Town to Pretoria, and in conversing with men possessing local experience, and a more or less intimate acquaintance with the physical and social conditions concerned, has materially tended to strengthen this conviction. The problem to be attacked is not, however, it must be understood, the carrying of a line for 4,000 or 5,000 miles through an unknown wild country, as is generally supposed. The distance which would have to be traversed for the completion of the African line is only 2,400 miles, and even this is conveniently divisible into three workable lengths of 800 miles each. Almost immediately there will be a telegraph in operation to Pretoria from Maritzburg, and that, therefore, may be taken to be the southern limit of the gap which has to be filled. The northern limit will soon be at Gondokoro, on the White Nile, to which point Colonel Gordon is pressing on the construction from the 8th degree of north latitude, above Cairo. The distance from Pretoria to Gondokoro, as the crow flies, is not more than 2,000 miles. The most practicable course in filling up this gap is from Pretoria to pass through Shoshong, the capital of the Bamangwato tribe, and Gubuluwayo, the residence of Lobengulu, supreme chief of the Amandabeles. From Gubuluwayo to Tete, the Portuguese settlement on the Zambesi, is certainly not more than 300 miles. From Tete to Zanzibar the line would pass through Blantyre or Livingstonia, the Scotch mission settlement on the Shire and Lake Nyassa. From thence there is a practicable route to the Zanzibar territory, near Cape Delgado, along the track which was traversed upon one occasion by Livingstone. From the frontier of this territory to Zanzibar could be passed, according to the testimony of Dr. Kirk, "with perfect ease and safety." Zanzibar, it will be remembered, is a great natural centre of commerce. It has a growing trade with Europe, Asia, and America. It has three lines of monthly steamers; namely, that to Mozambique, Natal, and the Cape; that to Aden; and the French line to Mozambique and Madagascar. The Port is also the head quarters of the eastern division of the African coast naval forces of Great Britain. The weakest link in the chain is undoubtedly that which lies between Zanzibar and Gondokoro, and which is, in itself, 800 miles long. The direct route for this lies over the Kilimandjaro Mountains, and thence round the north-eastern angle of Victoria Nyanza. But there is an alternative route for it by the caravan road from Zanzibar to Ujiji, on Tanganyika, and thence through the country of Uganda. This, although a somewhat more roundabout way, would have the great advantage of traversing one of the richest agricultural regions in the world. And yet again, if, for any unforseen reason, this part of the line proved impracticable, the wire might be taken along the coast from Zanzibar to the point which is immediately opposite to Aden. The obstacles which have to be specifically dealt with in a work of this kind are; the difficulties of transport through rough country; the dangers which may lurk in the interior of unknown territory; the opposition of hostile native tribes; the troubles incident to effective maintenance in a rude land; and the injuries to be apprehended from wild animals constituting the *ferœ naturæ* of the region. Obstacles of this class have, however, been all encountered and conquered in other instances, which are not by any means dissimilar to the work in Africa. The Russians have successfully carried a telegraph across the Steppes of Siberia. The Australians have done the same thing through the heart of their vast continent from Adelaide to Port Darwin. The North Americans have conveyed the wire across the prairie and the Sierra Nevada and Rocky Mountains. In South America the telegraph now runs from Buenos Ayres across the Andes to Lima, and through the heart of the tropical forests of Brazil; and, lastly, there is the great Indo-European telegraph, which is as well worked as any line in the world. In referring to the difficulties of transport, attention should, perhaps, be drawn to the hope which lurks for long overland lines in the new form of compound wire, which consists of steel encased in copper, and which will certainly suit admirably if it prove durable. Such a wire would electrically serve as well as an iron wire. A ton may be safely estimated as sufficient for twelve miles of line. On the telegraph lines of the Indo-European Company, subsidies to chiefs have practically quite obviated all risks of barbarous interference; the chiefs, indeed, in most places, have learned, under the operation of this system of subsidy, to look upon the telegraph line as a valuable kind of property to themselves, which it is expedient for them to guard with jealous care. In regard to the question of the unhealthiness of the country passed through, it will be understood that it is not necessary to have a white man at every telegraph post. There would only need to be stations about 200 miles apart, with runners between, with whom there would be some standing arrangement to indicate the condition of the intermediate section of the line. Constructing parties would only enter such fever haunts as the valley of the Zambesi at healthy seasons of the year, and, for inspection and maintenance, salted and acclimatised half-castes, and even natives, could be drawn upon for much useful service. So long as Kafir workmen can be kept from the canteen, looked after, and judiciously handled, they really make excellent line runners for telegraph maintenance.

The advantages which overland lines possess over submarine ones, when they can be carried out, are so obvious that it can scarcely be necessary to do more than touch upon them in the most cursory way. They cost much less money. In the case of an African overland telegraph, in all probability about £200 per mile, or, in round numbers, half a million sterling for the 2,400 miles, would be ample for the construction. The overland line is more reliable for service; its interruptions may be more frequent than those of a submarine cable, but they must be of very short duration, whilst a submarine cable once injured may remain silent for months. An overland line begets traffic along its route, and creates intermediate self-supporting stations. An overland line as soon as it is constructed constitutes a real solid property, which may be reckoned upon with a fair measure of certainty to last for years. The submarine cable, on the other hand, may fail at any moment, and become practically valueless. There can be no greater mistake than the old notion that a telegraph cable is out of harm's way when it is once at the bottom of a deep sea. The submarine cable, like everything else, has its own appointed term of life. When a cable is once put down in a deep sea its process of destruction begins; with the action of oxidisation upon its outer sheath of wires its weight augments, and its tensible strength diminishes from day to day. As soon as an old cable is lifted some distance from the bed of a deep ocean, the suspended weight becomes too great for its strength, and away it goes. This is of great practical consequence, because however well a cable may be made, and however well it may be laid, circumstances, in reality, arise which impair its electrical power, and necessitate its being overhauled from time to time. The lowest estimate that could be allowed for a submarine connecting trunk between South Africa and Aden would be £1,000,000 sterling;* and a repairing ship for its maintenance would cost £12,000 per annum.

As an alternative route, to guard against the evils of suspended communication under the influence of accidents, any second line of communication by a different course must always be of exceeding value. On this account, a connection with Aden is to be greatly desired, especially in the face of the fact that it is the one central spot in the great telegraph system, beyond all others, where the largest number of alternative routes converge.

* It is understood that the submarine cable which is to be laid from Aden to Zanzibar by the Eastern Telegraph Company, and which will run intermediately through Zanzibar, Mozambique, and Delagoa Bay, will cost between £900,000 and £1,000,000.

Telegraphy in South Australia.—The number of local messages transmitted in South Australia in 1878 amounted to 376,244. Of intercolonial telegrams 99,170 were sent, making a total of 475,414, for which cash to the extent of £32,425 was received in the colony. The rate in 1877 was rather less, as the corresponding number of telegrams in 1877 was only 408,477, and the cash receipts £27,747. It will be seen that there has not only been a large augmentation in the number of telegrams, but there has also been an increase in their average length. The enlargement in the business between the Australian colonies and Europe is particularly striking, the excess in the telegrams sent both ways amounting to about 5,000. The cable messages forwarded by all the Australasian colonies reached a total of 8,070 in 1878, the telegrams received numbering 9,371. The revenue from messages sent from Australia in 1878 was £69,396, and from those received in South Australia £77,949. Of these sums the proportion retained by South Australia was £16,391, more than £3,300 beyond the amount falling to her share in the previous twelve months. Not many stations were opened in South Australia during 1878, but several townships were placed in communication with Adelaide. They are Minlaton, Reedy Creek, Marrabel, Lucindale, Yankalilla, Hallett, and Goverment Gums. The amount of work done in the South Australian telegraph construction department in 1878 was considerably less than in 1877, but in that year it must be remembered the line to Western Australia was carried out. It is satisfactory to learn, however, that 156½ miles of line and 533¼ miles of wire have been added to the previous totals. The new lines constructed have been from Kooringa to Hallett, 19 miles; Kapunda to North-West Bend, 51¾ miles; Ardrossan to Port Victoria, 30 miles; and Adelaide to Blumberg, 25¾ miles; additional wires have been laid between Moonta and Kadina to the extent of 18¾ miles; Adelaide and Port Pirie, 168 miles; and Adelaide and Port Augusta, 220 miles.

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IMPERIAL TELEGRAPHS.

Recent events which have rudely directed attention to the want of rapid communication with one of our distant possessions have also recalled to our minds how well we are served in respect to all the rest. Sir James Anderson has opportunely emphasised this fact in a Lecture which we recently published, and the latter portion especially of which (*The Electrician* of April 5, 1879) we commend to the careful study of every person interested in Imperial and International Telegraphy. Rapidly, and almost unobserved, Colony after Colony has been placed on speaking terms with the mother country, until there is hardly a spot in our widely scattered Empire—the notable instance above referred to excepted—that cannot be reached by the swift-winged Electric Messenger. Places which, in spite of the expediting power of steam, still remained separated from us by an interval of months, are now, for the purposes of correspondence, approached in as many hours. The excitement created by the laying of the first great cable has hardly subsided, so recent does it seem, yet, in the brief interval between the accomplishment of that unprecedented feat and the present time, the Atlantic has received three additional cables, and many thousands of miles of wire have been launched into the deep seas of every quarter of the globe without calling forth more than a brief newspaper paragraph to notify the fact. The truth is that we had become familiar with the telegraph at home; its extension to lands beyond the oceans excited a passing wonder, and all the rest has been taken for granted. That the general public assumed, as a matter of course, that we could telegraph to South Africa, as to everywhere else, was evidenced by the pang of surprise which shot through the nation when far into the month of February last news reached us dated so long back as the fatal 22nd January. It was a painful awakening; but the warning has been taken to heart. A cable is now actually on its way to the coast of South-Eastern Africa.

The circumstances under which this particular district has been telegraphically neglected, point to the true causes which have promoted the growth of Submarine Telegraphy generally. Our extra-national Telegraphs serve a political purpose, it is true, a purpose indeed the full import of which no one at present can fully realise; but primarily they are the servants of commerce. How admirably they perform their duties, and in what unlooked-for ways the material wants of mankind are thereby provided for, are set forth in Sir J. Anderson's thoughtful lecture. It happens, however, that the Cape Colonies, although of considerable commercial importance, are, telegraphically speaking, on the road to nowhere; and up to the present time speculation has not been tempted to give them a cable all to themselves. The Cape is a great naval station, however; and, in the opinion of the late Colonial Secretary, of more value to us than even the Suez Canal. Thus the political and the commercial needs of the country have, for the first time, united in an enterprise which will relieve a Colony from a geographical disadvantage, and the Home Government from an exceptional source of anxiety.

It is, as we have said, impossible to estimate all the complex and far-reaching political consequences of the change which has been wrought by intercolonial telegraphy; but, seeing that the executive Government largely avails itself of this means of communication, it ought to do so in no niggardly spirit. We owe neither cables nor overland wires to Governmental benevolence; but, if private venture had not provided them, the Government must have done so. For good or for evil, the Telegraph exists; it cannot be dispensed with, got rid of, or restrained. When, therefore, a cable has become a political necessity, it is clearly the duty of the Government to lay it, with less of higgling and bargaining than we have heard about quite recently. Cables are costly, but they are cheaper than armies. And, on the whole, we think it will be found, in the long run, that, whether regarded as an instrument of war or as a preserver of peace, a cable will count for a good many hastily-equipped battalions. A trustworthy Telegraph is, in fact, cheap at any price; and it has the further merit of

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nowhere exciting opposition. The hardest thing we recollect ever being said about it was touching our Government relations with its great Indian dependency. "What," asked the critic, "is the use of your being able to speak to India, *if you have nothing to say?*" And a very pregnant and startling question it was. But its covert indictment was levelled at dumb statesmen, not against the Telegraph. And, indeed, this same Indian Telegraph managed to vindicate itself in an unanswerably beneficent way soon afterwards, when, but for its instrumentality, hundreds of thousands of lives would have helplessly perished of famine. Quite recently, too, what would not Natal have given to speak to us quickly in her hour of sore alarm? And we, on our side, are we not now lamenting that the counsel we would—or think we would—have urged on her last Christmas has hardly yet had time to reach her? We may neglect to "say" what we ought to say, or we may say it when it is much too late; but it is something to be *able* to make prompt amends when our attention is thoroughly roused.

It is probable, however, that, as we become more and more familiar with the power which the Telegraph places at our disposal, we shall exercise it oftener—we shall have more to say, and will say it more effectually. To borrow an illustration from the distinguished lecturer, if the Telegraph has made our foreign trade only an extended home market, it has transformed our whole Empire into only a *Greater* Britain. Governors can ask advice, give warnings, and receive instructions nowadays with almost as little delay as occurs between Downing-street and College Green. Urgent representations can no longer be pigeon-holed to wait a more convenient season. Many a border trouble, or local disaffection, foreseen for years by those on the spot, has been allowed to ripen into active hostility for want of that direct intercourse which, with rare exceptions, can alone command the attention of Cabinets that are busy with domestic politics at home. If the controlling of all Imperial affairs, both far and near, is to be called "Imperialism," certainly the Telegraph has helped to make Imperialism not merely possible but a practical necessity. It will lessen the responsibility of our Vicegerents, but it will quicken their vigilance. And if Ministers ought in future to be something more than party leaders, we may take comfort in the fact that they will have the telegraph at their beck and call to supply their shortcomings as Statesmen. Similarly, our foreign relations are being greatly facilitated and softened by readier interchange of views. Next to a personal interview, the Telegraph does in fact stand foremost as a reconciler and peacemaker. We have had some notable illustrations of this fact during the past two years. We have seen war actually avoided by a free use of the Telegraph; we have seen war brought on by not having used it sooner; and we have seen war precipitated by having no Telegraph to use. It is no mere fancy of the enthusiast, therefore, to credit the Telegraph with beneficially hastening that catholicity of nations which will enable mankind to live together, if not in love as brethren, at all events in peace like friends.

CORRESPONDENCE.

POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Every student will hail with satisfaction an attempt to clear of ambiguity the language of physical science. This object is specially dear to the teacher, who has found by bitter experience that the only road to clearness of ideas in the learner is exactness of language in the teacher. Ideas can be communicated only through language, the full force of which is understood on both sides. A teacher, then, who can put down in writing the exact steps by which he reaches a community of idea on any subject with his pupil confers a boon on the whole race of teachers. So far I must congratulate Mr. Baynes on the intention of his article in *The Electrician* of April 5, and I do this the more readily because I am sorry not to be able to follow his teaching on the special subject of potential, which he there illustrates.

He begins by defining Electrostatic Potential as that "property of an electrified body, whereby it requires work to be done when another electrified body is moved in its presence. It is this property of an electrified body which is called its Electrostatic Potential."

Now, as stated at first, the laws of potential are equally applicable to such forces as gravitation and magnetism, and, consequently, the general definition of potential must *mutatis mutandis* apply equally to them. Let us try. The potential of an attracting or magnetic mass is that property whereby it requires work to be done when another attracting or magnetic mass respectively is moved in its presence, and it is this property of an attracting or magnetic mass which is called its potential. Mr. Baynes proceeds:—"This property is a measurable quantity. * * * We can deduce a perfectly definite mode of measuring the electrostatic potential of a body, and we *measure* it by the work done *per* unit of positive electricity on a charged particle, which is brought up to the body from an infinite distance, the distribution of electricity on the bodies remaining unaltered during the motion."

By parity of reasoning we might expect that the potential of an attracting or magnetic mass is measured by the work done per unit of mass or per unit of magnetism respectively on a material or magnetic particle brought up from an infinite distance. Of course, Mr. Baynes never says this, and knows perfectly well that it is untrue, and that there is no such thing as the potential of an attracting or magnetic mass in the same sense that there is a potential of an insulated electrified conductor. Surely, then, it is a misuse of language to make a general definition which extends only over a limited portion of the class of phenomena included in the definition, just as if asked for the definition of a mineral I were to give the properties belonging only to iron. As a matter of fact, the definition quoted above of potential is no definition of potential at all, but is the definition either of electrification or of a field of force, while potential is a property not of a body, nor even of every imaginable field of force, but only a property of every point in certain fields of force such as we are acquainted with in nature. To speak then of the potential as that of the attracting system which (metaphysics apart) gives rise to the field of force around it is depriving the word potential of its real meaning; while narrowing down its measure to that which is applicable only to statical electricity is, at any rate, using an accidental instead of an essential property for the measure of the quality under consideration.

Waiving for a moment this objection—which I, nevertheless, think fatal to the soundness of the definition—I cannot pass over the steps by which the fundamental measure of electrostatic potential is arrived at. In the proof occurs this sentence:—"If the particle is now moved along the surface of the body to another point C, where it is brought to rest, no work will be done in the process, as the electrical force at all points of the surface is normal to it (otherwise the electricity could not be in equilibrium on the surface)." I suppose this must be an experimental truth, and I imagine it must be founded on the well-known experiment that there is no electrical force inside a charged conductor. If so, it must be assumed that the rate of change of potential is a measure of the force, an assumption which involves the very measurement of potential it was the author's object to arrive at. A clearer case of *petitio principii* I never saw. I hope I have misrepresented Mr. Baynes's line of reasoning; but, at any rate, the clause in parenthesis is one over which, I am afraid, even an intelligent beginner would stumble. Allow him however to have surmounted this difficulty, if he follow his teacher he will not have far to seek another. It is contained in the definition (I beg pardon, the measure) of potential at a point. We are told—"The result is just the same as if there were at the point a body charged to the electrostatic potential which is measured by the work done per unit of positive electricity on the particle which is brought up to it from an infinite distance, &c." I cannot tell what precise meaning to attach to the phrase, "*a body at a point.*" Does he really mean a pupil to conceive a body charged to a certain definite potential as explained, whose linear dimensions diminish without limit, the electrifiation at the same time growing smaller and smaller, so that when the body is reduced to a mere particle it may have such an indefinitely small electrification that its potential is the same as before? At any rate, it is only to such a body

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he can allude in the next paragraph when he speaks of the "potential of P," which he has just defined to be a point. Such a conception is, perhaps, not difficult to the mathematician, but out of place in "an elementary consideration of the subject," and even harassing to the pupil, who finds he has much to unlearn before applying the same order of ideas to other physical forces.

It seems to me that undue prominence is given in the article to the dimensions of the various quantities alluded to as if the dimensions were certain inherent properties of the qualities themselves, and not of our arbitrary means of measuring them. It cannot be borne in mind too strongly that they are merely constants of variation, useful only as guides in determining the values of a new set of derived units and measures in terms of new arbitrary units of space, time, and mass, or *vice versâ*. As is pointed out, the dimensions of electrostatic potential are $M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-1}$ in electrostatic measure, but $M^{\frac{1}{2}} L^{\frac{1}{2}} T^{-2}$ in electro-magnetic, a clear proof that dimensions give no clue to the nature of the quality, but only to its measure. Or, again, it is a convention derived from the law of gravitation that the mutual attraction between two particles, each of mass m, at a distance r shall be $\frac{m^2}{r^2}$, which must therefore be of the dimensions of force or $M L T^{-2}$, and, consequently, the dimensions of m are $M^{\frac{1}{2}} L^{\frac{3}{2}} T^{-1}$. But the dimensions of matter are M—an apparent paradox, though, of course, only apparent. Sufficient to show however how very unsafe it may be to appeal to dimensions to prove, for instance, that potential is not work. If there were the smallest ground for such an appeal, the loose expression, so severely criticised, "The capacity of a sphere in space is simply its radius," would be quite accurate. Absurd as it is taken literally (so absurd that no living person could take it so seriously), according to electrostatic dimensions of capacity it is perfectly correct, the dimensions being simply L—another proof of the extreme unsafety of dimensions as a guide in comparing or contrasting different qualities of bodies.

After all, perhaps, the confusion pointed out is only due to an attempt to define abstract properties in concrete terms. Take the fundamental definition of velocity (alluded to in a sharp criticism of a deliberately chosen definition of my own). We are told that velocity is the property of a body whereby it traverses space. I should have said that *motion* was the concrete property of a body whereby it traverses space. Velocity is one abstraction drawn from that motion, but only one out of many. Other abstractions drawn out of the same motion of the body traversing space are its form, mass, colour, heat, magnetization, electrification, momentum, energy, and such like, each denoting a particular property taken separately from other properties the body may possess. We must then, at any rate, in defining velocity, say that it is an abstraction in which we view the motion of a certain point in a body with reference only to the space the point traverses in a certain time. The measure of the velocity will, therefore, be in a constant ratio to the measure of the space passed over in a fixed time, and if it is measured in a suitable unit will equal the quotient of the measure of the space traversed by the measure of the time occupied in the motion. In the equation $v = \frac{s}{t}$ or $\frac{ds}{dt}$ the symbols are all numerical, and nothing else, they represent to us merely multiples of certain units of velocity, space, time, which are chosen consistently with this numerical relation. After an explanation of this kind has been given once, it is tedious to repeat the same thing over and other again for each new unit, and I do not think anyone is deceived as to the real meaning of such a phrase as that used by Clerk Maxwell, "the potential of a body *is* the work that would be done, &c.," any more than he is deceived when he begins by stating a dynamical problem. Let v be the velocity of the particle m at time t—knowing perfectly well that v cannot be the velocity, but only the measure of it, m not the mass, but the measure of it and t not the time, but the measure of it.

Take again momentum, which is best defined as proportional to the product of mass and velocity, and *is* that product when the units are chosen properly. To define it by a vague phrase such as quantity of motion, is only cumbering the mind with a new phrase conveying no new meaning. While, on the other hand, defining it as that property of a body which is acquired under the action of force, or any such like, is seen at once to postulate laws of motion, which are not contained in the abstraction called momentum, and which, therefore, do not belong to its definition. In fact bodies would still possess momentum in a region where Newton's laws were all of them reversed.

To conclude, the whole question resolves itself into this:—In the language of logicians, I would make the definitions of science only definitions of words, while Professor Baynes wishes them to be definitions of things. In this respect I believe I have no less an authority on my side than John Stuart Mill, who points out in his "Logic" chap. VIII. that "the most correct notion of a definition is a proposition declaratory of the meaning of a word." Again, speaking of what have been "erroneously called definitions of things," he says that these "along with the meaning of a name covertly assert a matter of fact." Again, he says, "it is not correct to call an expression of this sort a peculiar kind of definition. Its difference from the other kind consists simply in this, that it is a definition and something more."

The ideal scientific definition, then, is one which states in the most clear and unequivocal fashion the meaning which is to be attached to a word or a symbol quite apart from any postulates arrived at experimentally, which may be subsequently expressed most conveniently in terms of the definition. Of course, the historical origin of a definition is often a necessity which arises from some such postulate when first recognised. With the rest of the paper I entirely agree, especially with the remark on the vicious expression "Electromotive Force" used for difference of potential. With reference to the use of the word tension, for the present I only use it for the state of electrical strain in the interior of a dielectric under electrical force, a meaning more strictly analagous to its mechanical signification.

Rugby, April 10th, 1879. L. CUMMING.

THE DISCUSSION ON "POTENTIAL."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Dr. Lodge is quite correct in opining that I have no particular fault to find with the *expression* that "the capacity of a sphere in space is equal to its radius," or is "simply the radius;" but that what I am ready to deny is the *fact*. I take the expression "in space" to mean "at an infinite distance from any conductor connected to that pole of a charging source which is of opposite sign to that of the pole from which the sphere might become charged." I maintain that under such condition a conductor would have *no charging capacity*. The grounds upon which I base this conclusion are partly experimental and partly theoretical; and are strengthened by the exact analogy, hitherto, I think, very imperfectly recognised, which exists between the conductive and the inductive circuits. In the former, the law of Ohm, expressed by the equation $I = \frac{E}{R}$, is applicable; in the latter the analogous expression $Q = \frac{E}{R'}$, where R' is the inductive resistance, or the reciprocal of electrostatic capacity, is equally applicable. If the path of electrical propagation be prismatic, then the resistance, in either case, may be expressed as $r_1 \frac{l}{S}$, where r_1 is the specific resistance, l the length, and S the sectional area of the conductive or inductive medium. Of course it is practically impossible to confine inductive action strictly to a prism of dielectric; nevertheless it is, I think, quite possible to verify the above law experimentally. And from this law may be deduced the equation $C = \frac{1}{\log \frac{D}{d}}$ for the electrostatic capacity of a cylinder, such as a telegraph wire; D being the diameter of the insulating sheath, and d that of the conductor. The accuracy of this expression has been so perfectly verified by experiment that telegraphists can confidently predicate that the charging capacity of a wire *between the earth and the moon* would be almost inappreciable, and due merely to the proximity of "opposing surfaces" at each end of the line. If this view cannot be controverted, on what grounds of experiment or physical theory can we be required to assume that spheres "in space" would have charging capacities varying as their radii?

There are several paragraphs in the letter of Mr. Robert E. Baynes which render it, in my estimation, a valuable contribution to electrical literature; albeit there are others which I can admire only in the abstract, as artistic elucidations of a mathematical electricity which is "fearfully and wonderfully made." His admission of the fact that the dimensions of electrostatic potential (which is the same thing as that which some electricians still term *tension*) are those of the *square root* of force will be, I think, of historical interest, and his protest against the use of the term "electromotive force," applied to an artificial value which cannot, like force, be measured by a *pressure* or a *pull*, has my cordial sympathy—in spite of the suggestion of the term "potential difference."

I am sorry to have to differ from one portion of the letter of Mr. J. T. Sprague—that in which he suggests the substitution of $\sqrt{\text{energy}}$ for $\sqrt{\text{force}}$, as the expression for the dimensions of potential (or tension, or electromotive "force").

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That I have long held views in this direction, similar to those which Mr. Baynes has expressed in the fourth and in the concluding paragraphs of his letter, will be evidenced by the following quotations from my "Dictionary of Electrical Terms," part of which was printed in the numbers of the *Electric Telegraph Review* of which the dates are here given :—

"Oct. 15, 1870.

"The separation of electricity from matter, *i.e.*, the disturbance of electrical equilibrium, occurs only in virtue of an *electromotive force*, and under conditions which allow of *accumulation*, of *conduction*, or of *both* these methods of propagating the effect of the initiating force. The electrical effect is proportionate to this force (measured as E^2, and not as E, which is an artificial value corresponding to a potential velocity) and to the degree in which these conditions prevail; in other terms, the electrical *work* (potential, calorific, or mechanical) varies as $\frac{E^2}{R} = I^2 R$. In the former of these expressions, R may express either an inductive or a conductive resistance; in the second, I corresponds to *v*, and R to *m*, in the expression $(v^2 m)$ for 'visible energy.'"

"Nov. 12, 1870.

"The quantity of heat evolved in a circuit of constant resistance will be as the *square* of the quantity of electricity passing in a given time (I^2), or as (E^2) the square of what has been termed the electromotive 'force' of the source. But this 'force' (E) is, necessarily, a mode of attraction or pressure; and, when measured as an attraction, it is found to be of a purely artificial value, or merely an empirical measure, adopted in practice for the sake of its convenience and simplicity; the Electrical Force (F), acting, statically or dynamically, in a circuit, being really in all cases as E^2."—Yours, &c., D. G. FITZGERALD.

SOCIETY OF TELEGRAPH ENGINEERS' BALANCE SHEET.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your criticisms of the Society's balance sheet, which you designate as "a not very gratifying document," you appear to have misapprehended some of the figures which it contains.

Firstly, as regards the amount (£57 8s.) received on account of subscriptions to the Conference Reception Fund. Had you referred to the annual report, of which the balance sheet is virtually a part, and which is published in the same number of the Society's journal, you would have found it there stated that a sum of upwards of £500 has been subscribed to that fund. The amount actually received and to which you allude consists of subscriptions paid *in advance*, the members not having yet been invited to remit the sums for which they have set down their names.

The same remark applies to what you call the "ridiculously small sum of £6 18s.," received from subscribers for the Ronald's catalogue. The amount represented by the subscriptions for copies of that work is at present £145. It was never intended to ask subscribers to make any payment until the work is ready for issue, but some few have preferred to remit the price of the copies when sending in their names as subscribers. I may here mention that the printing of the catalogue is being rapidly carried on.

As regards the value of journals in stock, and which, so far from being exaggerated as you suggest, has been rather under estimated in the balance sheet, you may possibly not be aware that many gentlemen when elected into the Society desire to have a complete set, and it has, therefore, been the custom to print a considerable number of spare copies. That this has been a wise measure on the part of the council is evinced by the fact that the demand for "back numbers" has been so great that it has been considered expedient to increase the price of many of them.

The account for printing had, it is true, been allowed to grow to the large amount which you quote, but, as also stated in the report, it has, by the liberality of some members of the council, been discharged, and the debt transferred to them. This has enabled the council to enter into new arrangements as regards the printing, which will effect a large economy, and enable them to extinguish the debt in a very few years, even assuming that the annual income of the Society does not increase.

I request you to be good enough to insert these remarks in your journal, as I trust they will tend to remove the unfavourable inferences which you must pardon me for saying you have somewhat hastily drawn, and the publication of which in *The Electrician* might, if uncorrected, prove prejudicial to the interests of the Society which I have the honour to represent.—Yours, &c,

F. W. WEBB, Secretary.

Society of Telegraph Engineers, 4, Broad-sanctuary, S.W., London, April 15th, 1879.

THE WORK STORED UP (AS POTENTIAL ENERGY) IN AN ELECTROSTATIC CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* of March 1, of the present year, I made the following statement:—

"The tension (or potential) of a point or surface is twice the potential energy stored up in unit quantity of electricity when accumulated under the same tension."

In your issue of March 8, Dr. Lodge "modestly, but peremptorily and irrevocably, denies that the potential of a surface is measured by the potential energy stored up in unit quantity of electricity when accumulated under the same potential."

Your readers will perceive that your very able correspondent and myself here differ upon a question which, if "potential" be defined, is essentially one of experimental fact, and one, therefore, which should not be allowed to remain undecided. If I am wrong, I should like to be corrected; but I admit that the *onus* of proof fairly devolves upon me.

Now, in looking over the examination questions which I have from time to time propounded to my advanced class, I find several which, directly or indirectly, involve the point at issue. From these questions I select the following, as it relates to a simplified case of charge, and one which I think may be accepted as typical:—

"One terminal of a Latimer Clark standard cell, and one terminal of a condenser having the capacity of 2·5 microfarads, being connected to earth, the other pole of the standard is connected with the remaining terminal of the condenser. What quantity of work, in foot pounds (*a*), and also in British Association units or joulads* (*b*), will be stored up in the condenser charge?"

The answer which I have accepted as correct is:—

(*a*). ·000001957 foot-pound.
(*b*). 2·6535 microjoulads.

It will, I suppose, be admitted that the "potential" of the condenser-surface insulated from earth, or that of any point of this surface, is simply the electromotive force of the standard cell, viz., 1·457 Volt. (At all events, any practical electrician would say that the insulated surface was charged to this tension, or potential; and any scholastic theory teaching otherwise would, I think, have but small chance of becoming accepted.)

But, calling E this tension or potential, W the work stored up in the charge, Q the quantity of electricity accumulated, and *k* a constant, applicable when the work is expressed in foot-pounds, we have, in this case—

$$(a). \quad E = \frac{\cdot 000001957 \times 2}{Q\,k} \text{ volt},$$

$$(b). \text{ or } E = \frac{2 \cdot 6535 \times 2}{Q} \text{ volt},$$

as I propose to show presently.

And the proposition I maintain is that—

Generally, if T *be the tension (or potential) of a charge,* Q *its quantity, and* W *the work done when the charge flows to earth, we have* $T = \frac{2W}{Q}$ *with any absolute system of units (or with the derived B.A. units), or* $T = \frac{2W}{Qk}$ *with any arbitrary system of units.*

I will now give an answer to the above examination question—such as I should expect from my advanced class.

(*a*). 1. The formula for work in foot-pounds done by a *current* is:—

$$W = \frac{E^2}{R}\theta k = E I \theta k = \frac{I^2}{R}\theta k = E Q k,$$

Where W = work in foot-pounds,
E = electromotive force in volts,
θ = time in seconds,
Q = quantity in webers,
R = resistance in ohms,
and k = ·7375.

2. In electrostatics, since one-half of the energy of a current of charge is necessarily expended in the accumulation of the charge, this formula becomes $W = \frac{E Q k}{2}$.

But, calling C electrostatic capacity, $Q = C E$.

Therefore $$W = \frac{C E^2 k}{2}. \quad \ldots\ldots\ldots \text{(I.)}$$

and $$E^2 = \frac{2W}{Ck}, \quad \text{or } E = \frac{2W}{Qk}. \quad \ldots\ldots \text{(II.)}$$

3. When one pole of a source is connected to earth, the tension

* *Vide The Electrician*, Vol. I., No. 20, p. 236.

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(or potential) of the charge communicated by the free pole, or the tension of the surface charged, or the tension of any point of this surface, is equal to the electromotive force of the source.

4. The E.M.F. of Clark's standard cell is 1·457 volt. In the given case of charge, the work stored up will, therefore, be, by formula (I.):—

$$W = \frac{2{\cdot}5}{10^6} \times \overline{1{\cdot}457}^2 \times {\cdot}36875 = {\cdot}000001957 \text{ foot-pound.}$$

(*b*). 5. In the B.A. system of units we have simply,

$$W_{,} = \frac{C E^2}{2} \text{ B.A. units of work, or joulads,}$$

and $W_{,}$ will be in microjoulads if C is in microfarads. Thus, in the above case we have:—

$$W_{,} = \frac{2{\cdot}5 \times \overline{1{\cdot}457}^2}{2} = 2{\cdot}6535 \text{ microjoulads.}$$

The quantity of electricity accumulated will be—

$$Q = C E = 2{\cdot}5 \times 10^{-6} \times 1{\cdot}457 = 3{\cdot}6425 \text{ microwebers.}$$

Supposing E to be unknown, it can be calculated from the work stored up in the charge, by the formulæ:—

(*a*). $$E = \frac{2W}{Qk} = \frac{2 \times 1{\cdot}957 \times 10^{-6}}{3{\cdot}6425 \times 10^{-6} \times {\cdot}7375} = 1{\cdot}457 \text{ volt;}$$

or (*b*). $$E = \frac{2W_{,}}{Q} = \frac{5{\cdot}307 \times 10^{-6}}{3{\cdot}6425 \times 10^{-6}} = 1{\cdot}457 \text{ volt.}$$

Now I maintain that every case of charge involves two opposing surfaces, or what is virtually a condenser having a certain charging capacity, and that a conductor cannot be said to have, of itself, any charging capacity. If this be true—and I do not fear any disproof in this direction—the above case of charge may be taken as typical; and what is true in that case will be true generally. Therefore, *the tension (or potential) of a charge is equal to twice the potential energy stored up in unit quantity when accumulated under the same tension.* And the tension (or potential) of a point or surface is simply that of the static charge accumulated at the point or surface in question. Q.E.D.—Yours, &c.,

DESMOND G. FITZGERALD.

6, Akerman-road, Brixton.

ELECTROSTATIC POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Dr. Lodge does not quite see my meaning when I say that "there cannot be any difference in kind between the work done on one unit and the work done on fifty units," for he asks if there is, "then, no difference between work done per unit of something and work simply." It is this slight alteration of *per* for *on* which gives the idea of a *change-rate* of work instead of that of work itself, thus pointing to a change of dimensions, and I was only lamenting the fact that the word *on* seems to be generally preferred by the text-books.

But, again, the words "work done per unit of something" raise in my mind no other physical conception than that of work itself, and I cannot, therefore, with any degree of comfort, say that work per unit of length is force, and that mass per unit of volume is density. I feel, however, quite clear if I say "that agency which is measured by the work it does per unit of length is force," or "that property of a body which is measured by the mass of it per unit of volume is density," and find that definite conceptions spring up in my mind in correspondence with the definitions. I find, too, that my pupils appreciate definitions expressed in this form, even in the cases wherein experience has given them practical though vague notions, especially after having been pressed as to the meanings of the terms they use.

I think it would be impossible to choose units which would make the dimensions of potential equal to $\sqrt{\text{energy-dimensions}}$, as Mr. Sprague suggests, for this would require potential to be electricity. Further, as the equation potential $= \sqrt{\text{force}}$ is only dimensional, and that, too, on the electrostatic system of units only, I cannot assign it more value than as a *memoria technica*.—Yours, &c.,

ROBERT E. BAYNES.

Christ Church, Oxford.

QUADRUPLEX TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I must request to be allowed to correct the statements contained in a paragraph appearing amongst the "Notes" on p. 145 of your issue of the 15th February last.

The split battery system of duplex working now in use on some of the Government lines in India was devised by Mr O. Heaviside, of Newcastle-on-Tyne, who figured and described the method in the *Philosophical Magazine* of June, 1873. The only modification due to Mr. Briggs is the use of a short-circuiting key to produce the signals, a device first employed by Kramer in connection with double sending.

Mr. Briggs's split battery method is identical with Gintl's old and well-known "chemical method," which labours under the fatal defect that the capacity of the line cannot be balanced by the use of condensers. This method was never employed in India, and if the quadruplex you refer to is based on that it will be useless except for lines so short as to have no sensible capacity. If, on the contrary, the quadruplex is based on Heaviside's split battery method, it will be free from this defect.

The split battery method is conjugate to the differential method; it is, in fact, a differential method, in which the battery is differentiated instead of the instrument. The mathematical formulæ expressing the stability of balance of the two methods are identical, the resistance of the battery and the resistance of the instrument being simply interchanged. Neither method is, therefore, absolutely more stable in balance than the other; and this relative stability simply depends on the relative resistances of the battery and instrument. If the resistance of the battery is greater than the resistance of the instrument, then the split battery balance is the more stable, and *vice versâ*.

The only successful system of currents for quadruplex working is Edison's, which involves reversals of the battery poles. This fact renders any split battery method peculiarly unsuitable for quadruplex working; because, instead of the battery reversals being made in a *null* branch, as in the bridge and differential methods, they have to be made in a branch occurring between the line and the receiving instrument. Every time the battery is reversed the balance will be destroyed for a moment (the moment during which the battery poles are short-circuited), and the incoming signals will be disturbed. Bad or variable contacts will also interfere with the incoming signals. For quadruplex workings, therefore, the split battery is far inferior to the differential method.

I believe you are wrong in considering the fact of its being a split battery method to be the strong point of the quadruplex under consideration; this, I think, will be found in Mr. Winter's double-tongued polarised relay, which he has devised to supersede Edison's non-polarised relay, and Gerrit Smith's single-tongued polarised relay. When recently in Madras, I gave Mr. Winter an opportunity of trying his relay on one of the Bombay wires (800 miles), and from the excellence of its performance, I believe that it has a very successful future before it, and, when combined with differential duplex, will afford the most effective quadruplex yet suggested.—Yours, &c.,

K. S. BROUGH, Lately Officiating Electrician, Indian Government Telegraph Department.

Alipore, Calcutta, March 21st, 1879.

"THE NEW THEORY OF TERRESTRIAL MAGNETISM."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The *Engineering* critic may not have understood his subject, and Dr. Muirhead may be right in rebuking him, but I and several intelligent friends who have been consulted are in the same fix, but, instead of criticising, we would respectfully ask for further information. The publication of the original paper will, no doubt, set us right, but with nothing but Dr. Muirhead's exposition before us we are faced with several difficulties which his paper does not remove. I will state one, the chief of them. Granted that statical electricity in mechanical motion acts like a current in creating a magnetic field. We have a clear idea of what this means—the charge must move or the field must move; or, if they both move, their velocity of motion in relation to each other must be different. These are the conditions. Now we fail to see or to imagine the possibility of fulfilling such conditions in a body like the Earth, which moves in mass. Admitting all that is alleged concerning the different linear or the different angular velocities of the Earth's surface and its interior, where do you get the kind of motion requisite for producing a magnetic field—at all events, *inside* the earth? A ray of light from the surface inwards to the axis would illuminate *the same points* for ever; and, this being the case, we cannot understand how the static charge on the surface is able to induce in the way supposed, a magnetic field anywhere beneath it. In order that Dr. Muirhead may the better understand our difficulty I will put it to him in this way:—The statically charged felloe of a revolving wheel would magnetise the (fixed) axle, but would not, we imagine, magnetise the nave, or the spokes, or the intervals between them. And what is true of a wheel would be true of a globe.—Yours, &c.,

J. LAISTER.

April 5th, 1879.

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PROPOSED TELEPHONE RELAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I don't think the proposal which comes to you from Candahar would answer. That any of our Afghanistan army find time to think in peace about our telephonic difficulties here gives us a good deal of pleasure. But a little further reflection will satisfy your correspondent probably that if no one has yet been able to detect any movement of the diaphragm at all, the force at our disposal is obviously not sufficient to cause a coil to "suck in" a core which shall in turn exert pressure upon a medium of variable resistance. Besides this, there is reason to believe that we cannot add to the volume of sound without loss of distinctness. A good telephone is audible enough when put to the ear, and nothing could be handier.—Yours, &c.,

April 7th, 1879. JUDEX.

THE SOCIETY OF TELEGRAPH ENGINEERS.

The discussion of Mr. Sivewright's paper on "South African Telegraphs" was resumed at this society's meeting on Wednesday the 9th inst., the president, Lieut.-Col. Bateman Champain, in the chair. Mr. W. H. Preece, Dr. Siemens, and the chairman were the chief speakers, the two first named gentlemen confining their remarks exclusively to Mr. Sivewright's scheme of overland telegraph for connecting the Cape Colonies with Europe. Mr. Preece warmly defended his old comrade, and made the best that could be made of the case for a land as against a submarine wire. Dr. Siemens would have preferred that the sea route *viâ* India had been chosen rather than that which has been decided upon; but in any case hoped that the mistake would not be made of selecting shallow waters for the cable now being laid—an expression of opinion in which the chairman heartily concurred, deep sea affording by far the greatest security against any of the several ordinary causes of breakage. On the whole, the speakers were agreed in thinking that under present circumstances a submarine cable was to be preferred; but that an overland line was by no means an impossibility, and ought to be attempted before very long.

Professor Hughes's paper on "Induction" was down next for discussion; but as no one appeared ready to offer any observations, it was decided that Mr. Preece should communicate to the meeting such portions of a paper promised by him on the same subject as might elicit some remarks. Mr. Preece described several careful and interesting tests for induction which he had made both in underground and overhead wires. He drew particular attention to, and explained the difference between the two kinds of induction to which our wires are subject—electrostatic induction and electro-magnetic induction, and pointed out that although we knew that the latter existed it had hardly been noticed, and rarely occasioned any inconvenience. As regards electrostatic induction, the case was different; it caused retardation of signals, and we have to resort to certain well-known expedients to correct it. But the general tenor of the speaker's observations went to show that, at all events for the telegraph system of this country, the remedy suggested by Professor Hughes was for an evil which we do not experience, and was not capable of mending that which really does give us some trouble. In conclusion, Mr. Preece described some experiments upon wires running near to others conveying a current for electric lighting. He found, as he had anticipated, that the induction set up, even at distances of eight or ten feet, was enormous, and that as the proximity of these wires to ordinary working circuits would effectually disable them. The Post Office had decided to oppose all Electric Lighting Bills in Parliament, unless a clause were inserted giving the Postal Telegraph authorities control over the direction taken by any fresh wires laid down for lighting purposes.

Professor Hughes, in replying, explained that the experiments set forth in his recent paper had been made chiefly with a view to overcoming the difficulties of working in France, where electro-magnetic induction was felt very seriously—a circumstance which he attributed to the fact of the wires there being carried in one plane. He expressed, with some warmth, his disappointment that no representative of Mr. Edison was present to substantiate the claim put forward by him in his published telegram. It had placed him, Professor Hughes, in a painful position; but while he was always ready to give way to the claims of others, if fairly their due, he did not feel called upon to do so in this instance, as he could discover no grounds for Mr. Edison's pretensions, and nobody had come forward to champion that gentleman's cause. He wished to state, however, that he had not published his researches with the least idea of urging claims to the exclusion of anybody. For purely practical reasons connected with the working of his type-printing instrument, he had for fifteen years been investigating the phenomena of line induction; and what he had placed before the meeting was simply one series of conclusions which he had arrived at after many hundreds of experiments. Some were feasible and some were not; but, at any rate, nobody would suspect him of filching from Mr. Edison or anybody else.

The Professor's remarks elicited warm sympathy, and many persons remained to inspect his instruments.

EDISON'S ELECTRIC LIGHT.

(From the *New York Herald.*)

SEVERAL RECENT IMPROVEMENTS IN THE SYSTEM—A DISCOVERY OF IMPORTANCE—LESS THAN HALF THE COST OF GAS.—The first practical illustration of Edison's electric light as a system has just been given. For the past two nights his entire laboratory and machine shop have been lighted up with the new light, and the result has been eminently satisfactory. In the chemical portion of the laboratory two of the incandescent lights supplied the place of the five gas jets ordinarily in use there, and in the machine shop, a building 125 feet long by 25 feet wide, twelve of the new lights did the work of the eighteen gas burners previously used. The light given was clear, white and steady, pleasant to the eye, and of such character that colours could be readily distinguished. None of the unpleasant glare so noticeable in the carbon light was visible. The electric lamps were regulated so that each gave a light of from eighteen to twenty candle power in intensity, but the purity of the light made the intensity appear even higher. The generator used was the ordinary Gramme machine, said to consume two and one half horse-power, but which in reality has been found to consume three horse-power. The exhibition was witnessed by some of the leading directors of the company controlling the patents, together with a few scientific friends of the inventor. All were much pleased at the result.

THE LATEST IMPROVEMENTS.—The progress made during the past two months by Edison has been quite marked. The light, instead of being at a standstill, as was generally believed, has in reality been greatly developed. The most prominent of the improvements is one relating to the platinum and iridium coil. By a discovery, pronounced by experts who have seen it as of great scientific importance, Edison has succeeded in practically creating a new alloy—one that possesses properties hitherto unknown. Its melting point is much higher than that of any known metal. This discovery has proved most valuable in connection with the electric light. Previously the best result which the inventor could obtain per horse-power was four lights, but by the use of this new alloy he now obtains with ease six lights per horse-power, and makes it possible, under certain conditions, to obtain as high as eleven.

A BETTER GENERATOR NEEDED.—One of the chief difficulties Edison has had to contend against has been the want of a proper generator for his peculiar method. In the course of his experiments with the light he has used several, and constructed two or three of his own, but none of them have come up to his requirement. The one giving the best satisfaction thus far is the Gramme machine; but even that does not develope electricity with sufficient economy to satisfy him, although from that machine he has obtained, as above stated, at the rate of six lights per horse-power. He continues confident that in a short time he will have succeeded in constructing a generator that will give much better results. But even with the Gramme, imperfect in many respects for incandescent lighting as it is, he manufactures the light at a cost of a trifle over one cent per hour for six electric lights. His mechanics are now constructing a new generator, which promises to yield much better results, so far as economy is concerned.

THE STYLE OF LAMPS USED.—Since beginning work on the electric light, Edison has devised more than a score of lamps of different styles, but one by one they have been laid aside as not coming up to his conception of what he ought to have. There now remain only two styles, which closely compete with each other in point of excellence. In both there is a small glass chamber, through which passes the little coil which is made incandescent by the electricity. One of the lamps resembles the ordinary student's lamp. The other is of globular form and hardly as handsome. The essential construction of each is practically the same, although there are some few minor points of difference. The regulator or contrivance by which the electricity is turned off and on has been improved, and is now much more simple than it was originally, the expansion of the air in the globe serving to work it.

LESS THAN HALF THE COST OF GAS.—The recent improvements which have been made by the great inventor have neces-

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sitated the changing quite materially of the figures upon which the cost of electric lighting has previously been based by him. Lately he has obtained estimates from different builders of the cost of engines, boilers, dynamo machines, and the other necessary appliances. With their guarantees, and with the experiments already made by the lamps now in use (the horse-power consumed being measured by a dynamometer and the resultant electricity by an electro-dynamometer, the whole reduced to so many foot pounds per candle power), he has been able to make the necessary estimates. The results are certainly startling, as compared with gas, as they show that gas must be made and stored in the gasometer at fifteen and a half cents for each 1,000 feet to compete with his system, and with a possibility of a further reduction by improvement. In one of Edison's electric burners equal to sixteen candles there is consumed 2,560 foot pounds per minute, whereas a gas jet of equal power consumes 48,000 foot pounds, or eighteen times more energy to produce the same effect as is produced by the electric light. To put it in more popular terms, the present estimates as to the expense of electric lighting under Edison's system, as made by him, figure the cost of electricity as compared with gas at less than one-half, or, supposing gas to be furnished at the rate of $2 25 per 1,000 feet, an equal supply of electric light can be furnished for $1, leaving at that price a fair profit for the company supplying the electricity. The figures put forward by the gas companies Edison claims are based on error. Those who make them do not, he says, understand his system; and he further claims that in many instances they estimate twenty-four hours per day as the daily consumption, when, in point of fact, the consumption of gas or electricity will not average for all the burners more than three or four hours at the most.

INCANDESCENCE V. CARBON.—Among the experiments frequently tried of late in the laboratory is one showing the essential difference between light produced by the carbon process and that by incandescence. In the centre of the laboratory, suspended from the ceiling by wires, is a carbon apparatus, said to emit a light of 4,000 candle power. Last night the twelve incandescent lights were frequently compared with it to show the relative quantities of light. The light from the carbon gave apparently not more than three or four times as much light as that given by the incandescent lights. What it did give, however, was not nearly as effective for practical purposes as were the twelve incandescent lights.

By the latter the mechanics were enabled to do their work with as much facility as if it was day, but during the time the carbon light was shining it was noticed that many of the workmen were unable to work, the flickering, unsteadiness and sharp shadows from the carbon process being painful to the eye. Immediately in the vicinity of the carbon the light was brilliant and intense, but at a distance of thirty or forty feet it was very much decreased. The scientists who witnessed the comparisons were unanimous in pronouncing in favour of incandescence as much better adapted for practical uses.

GETTING READY FOR THE PUBLIC.—The work in the laboratory during the past month has been assiduous, the machinery and mechanics being kept going until midnight every night. Only two things, Edison says, are now necessary before the light can be given to the public. The first is the standard lamp to be used and the second a better generator than the one now in operation. Neither of these requirements is regarded by him as difficult of attainment. Indeed, both might be dispensed with, he states, and the system be now put in practical operation everywhere, and electricity supplied at less than half the cost of gas, but, feeling satisfied that a delay of a few months will enable him to get the system down to even greater economy, he prefers to send it from the laboratory as near complete as possible. The undertaking to light up Menlo Park will be commenced in a few weeks. Mr. Batchelor, Edison's chief assistant, who has full charge of the details of the work, has already made the estimates and given the preliminary orders for the accomplishment of the same.

WEST COAST OF AMERICA TELEGRAPH COMPANY (LIMITED).

The second ordinary general meeting of the shareholders of the above Company was held on Thursday, the 10th inst., at the offices, No. 98, Cannon-street, under the presidency of Mr. Neil Bannatyne. The salient features of the directors' report have appeared in *The Electrician*.

The CHAIRMAN, in moving its adoption, said the report was rather long. The directors had gone as fully as possible into all matters connected with the Company, so that the shareholders might have as clear an idea of the exact position of the concern as the directors were able to supply them with. The report was, therefore, so full that, if he made any further observations at the moment, he should only recapitulate the statements it contained. He would, however, be happy to reply to any questions, and, in that manner, perhaps, give further information.

Mr. JOHNSTON seconded the motion.

Mr. SMALL said that the capital was stated at £300,000, while the cost of the cables, land lines, and instruments was set down at £425,000. He regretted that there was £150,000 debentures, the interest on which had to be provided before the ordinary shareholders received anything. He feared it would be some time before they received anything.

Dr. BEATTIE was not so despondent. The debenture-holders had voluntarily relinquished 2 per cent. of the interest to which they were entitled, and now received only 8 per cent., and with an improvement in trade he trusted that the ordinary shareholders would receive some dividend. He asked how the steamer, the Retriever, was employed.

Mr. LUNDIE asked what effect the war between Chili and Bolivia would have on the Company's traffic.

The CHAIRMAN, in reply, said that the balance-sheet clearly showed the amount of the capital and how it had been expended, and it also showed what really were the assets of the Company representing the capital. The object of the directors had been to place the accounts on as sound a basis as possible, and they had written off out of revenue all the preliminary expenses of forming the Company, and the working expenses of the steamer preparatory to her being placed on the station; so there were no assets which were not really available assets. When they had a surplus of revenue they would be in a position to pay a dividend on the ordinary shares. They could not prophesy when they would be able to pay a dividend on the ordinary shares—it depended entirely on their traffic. When the cables were laid down business was in a more active state in Peru than had been the case ever since, and the traffic had certainly not come up to the expectations originally formed of it, partly from this cause and partly from another cause not within their control—the interruptions to neighbouring lines. The steamer had made one voyage carrying water, and she had also been employed in carrying cargo and towing. She was fitted up and ready for employment in any of the ways stated in the report. She was an excellent vessel. All their cables were in working order, and the cable in store was in perfect electrical condition. They could not tell what effect the war between Chili and Bolivia would have on their traffic, but he thought he might say that for the present month it would have a very favourable effect on the local traffic. The debenture interest was 8 per cent. on £150,000. Any one could see what that amounted to, and the position of the ordinary shareholders as to dividend. Their expenses were excessively small, and it would be their policy to keep them down as much as possible consistent with efficiency.

Mr. GRAY remarked that the Company's cables extended from the capital of Peru, past Bolivia, on to the capital of Chili, Valparaiso, touching at various intermediate posts. Before war was declared they were asked to connect Autofogusta, one of the Bolivian ports. He then referred to the causes out of which the war arose, and afterwards stated that there would probably be one length, from Autofogusta to Iquique, through which no messages would go; but he anticipated a great local traffic. He felt satisfied that neither of the Governments would injure the cables, because in peace they derived such great benefits from them. In fact, the Presidents of Chili and Peru had told him that they would do all they could to preserve the cables.

The report was then unanimously adopted. The other business was disposed of, and the meeting closed with the usual complimentary vote.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices April 16.		Business Done Week Ending April 16. Highest.		Lowest.	
Anglo-American	54,	¼	55¼		54¼	
Do. "B"	84¼,	5¼	86		85¼	
Do. "A"	24¼,	5	27		26	
Brazilian	6¼,	¼	6 13-16		6¼	
Cuba	8,	¼	8¼		—	
Do. Ten per Cent. Preference	15,	16	—		—	
Direct Spanish	1¼,	2	—		—	
Do. Ten per Cent. Preference	10¼,	11	—		—	
Direct United States	10¼,	¼	10¼		—	
Eastern	7¼,	¼	7¼		7¼	
Do. Six per Cent. Debenture	102,	5	—		—	
Do. Five per Cent. do.	100,	2	101		—	
Do. Six per Cent. Preference	11¼,	¼	12		11¼	
Eastern Extension	7¼,	¼	7 9-16		7¼	
Do. Six per Cent. Debenture	106,	9	—		—	
German Union	7¼,	8¼	—		—	
Globe Telegraph and Trust	4 13-16,	15-16	4 15-16		4¼	
Do. Six per Cent. Preference	10 13-16,	15-16	11		10¾	
Great Northern	8,	¼	8¼		8 3-16	
Indo-European	21,	2	—		—	
Mediterranean Extension	2¾,	3¼	—		—	
Do. Eight per Cent. Preference	9¼,	¼	—		—	
Reuter's	9¼,	10¼	—		—	
Submarine	215,	25	222		221	
West India and Panama	1 9-16,	11-16	1 11-16		—	
Do. Six per Cent. Preference	8¼,	¼	8 7-16		—	
Western and Brazilian	3¼,	4¼	—		—	
West. Union Seven per Cent. 1st Mort.	114,	18	—		—	
Do. Six per Cent. Sterling	101,	3	—		—	

TRAFFIC RECEIPTS FOR MARCH, 1879.

Companies.	March 1879.	March 1878.	Increase.	Decrease
Anglo-American Telegraph Company	47,550 estd.	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,100 estd.	3,517	—	417
Direct Spanish Telegraph Company	929	880	49	—
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	26,185	23,112	3,073	—
Eastern Telegraph Company	41,225	38,201	3,024	—
Great Northern Telegraph Company	15,401	—	—	—
Submarine Telegraph Company	9,790	10,055	—	265
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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NOTES.

PROGRESS IN JAPAN.—According to the *Homeward Mail* the telephone is now in general use in the public departments of Japan.

ROYAL ENGINEER TELEGRAPH CORPS.—Our notice under this heading last week was, we are informed, premature. Major Webber has not yet started for the Cape.

CYPRUS TELEGRAPHS.—Mr. John Pender, M.P., the Chairman of the Eastern Telegraph Company, has just completed the inspection of the Cyprus and Malta telegraph stations.

MAGNETIC VARIATION.—M. Flammarion calls attention to the singular fact that the daily variation in the magnetic needle recorded in Paris is different from that recorded elsewhere; that, in fact, the amplitude of the variation has remained stationary there, while everywhere else it has of late years been gradually diminishing! Is it possible that magnetic observations are *not* "done better in France?"

THE STRING TELEPHONE AND DEAFNESS.—Mr. H. A. Severn, of Herne Hill, writing to a contemporary, says that deaf persons—or, at all events, persons very hard of hearing—can hear even a whisper spoken into a string telephone, the string of which is carried to their forehead and fastened round the head in a loop. The instrument he uses is a tin pot about the size of a tumbler, having a parchment diaphragm.

A CHURCH STRUCK BY LIGHTNING.—A very heavy thunderstorm passed over a part of Bedfordshire on April 8, when the lightning struck the tower of Henlow parish church, which is a very handsome one, passing down the interior of the tower, rending and tearing it; took a course through the body of the church, cutting up the woodwork of the seats into splinters, and made its exit through a window in the east end, which it knocked about sadly.

REPAIR OF AN OLD CABLE.—The cable between India and Ceylon, thanks to the energy and perseverance of Mr. R. S. Brough, has been put into good working order. It is thirty miles in length, and is a Hooper's core cable, laid in January, 1867. Every one else had condemned it as past repair; but Mr. Brough's belief was that if it were provided with new shore ends it would be all right, and the result has entirely justified his expectations. Its insulation originally was 7,000 megohms per mile; and it is now 2,550 megohms per mile, after being down twelve years—a fact interesting as showing the value of Hooper's proposed substitute for gutta percha.

SUBMARINE CABLES TRUST.—The eighth ordinary annual meeting of certificate holders will be held at the City Terminus Hotel, Cannon-street, London, on the 1st day of May, 1879. The revenue for the twelve months, including a balance of £2,603 0s. 1d. brought from last year's accounts, has amounted to £26,165 15s. 7d. £1,890 was expended in the purchase of twenty certificates, £2,000 has been deducted for expenses, leaving a balance of £22,275 15s. 4d. Of this sum £10,362 has been applied to the payment of the coupons due on the 15th October, 1878, and the balance of £11,913 15s. 4d. is carried forward. The sum required to pay the coupon due on the 15th inst. is £10,362.

COST OF PUTTING UP LIGHTNING CONDUCTORS.—M. Melsens recently addressed to the Académie des Sciences a note relative to the cost of establishing lightning conductors. A system devised by himself for safeguarding buildings by means of these conductors is to be applied to the vast barracks at Etterbeck, by Brussels, having an area of 42,000 metres, of which 20,000 are occupied by buildings. The estimate for all the materials for this work amounts to only 4,200fr. By augmenting the number of conductors in the ratio of 3 to 2, and allowing liberally for all the labour required, the sum total amounts to less than 6,000fr. M. Melsens points out that the area covered with buildings here amounts to nearly half the covered superficies of the *abattoirs* of La Villette at Paris, where the cost of establishing the lightning conductors was 71,655fr.

ELECTRODYNAMIC INDUCTION.—It is a common impression among electricians that a telegraphic conductor can be withdrawn from the inductive influence of neighbouring conductors by metallic envelopes which are connected with the ground, but H. De Mauex tried some experiments in the month of February, 1878, preparatory to the establishment of the telegraphic service of the French Exposition, which led him to the discovery of a new law. In electrostatic action, the induction may be prevented by the proposed method, but the law relative to electrodynamic induction is thus stated: In a closed circuit the intensity of the current, which is determined by the induction of a cylindrical conductor upon another of the same form, cannot be changed even by surrounding one or both of those conductors by a concentric metallic envelope communicating with the ground through its entire length.—*Comptes Rendus.*

THEORY OF THE MICROPHONE.—A theory of the microphone is given by H. Aron ("Wied. Annalen," vi., 403). The action of the microphone depends on the vibrations of the carbon causing changes of resistance which give rise to fluctuations in the current. These fluctuations are indicated by the receiving instrument, which is generally a Bell telephone. Assuming that the changes of resistance and current strength are indefinitely small in comparison with the total resistance of the circuit and the strength due to the battery respectively, the author arrives at the following results:—(1) The different wave-systems that traverse the circuit are superposable; (2) the change of phase is greater the higher the pitch of the note; (3) the amplitude, however (that is, the intensity of the current-change), diminishes as the pitch rises, and the more so as the resistance and the electrodynamic potential are greater. Large coils, therefore, in the circuit, are a disadvantage, especially if they have iron cores.

MODIFICATIONS OF AMPERE'S LAWS.—Max Margules has communicated to the Vienna Academy the results of his researches upon "The Theory and Application of Electro-Magnetic Rotation," which he embodies in the two following laws: 1. If the pole of a magnet rotates in the neighbourhood of an unclosed conductor, about an axis which is within the magnet, a current will be induced within the conductor; but if a rectilineal conductor is turned about its own axis, in the

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neighbourhood of a magnetic pole, no current will be produced in it. 2. The rotation of a magnetic pole around a rectilineal conductor induces no current, but the rotation of the conductor about the pole produces an induced current. The first portion of the first law is a simple inversion of Ampere's statement of the law of electro-magnetic rotation; it has also been demonstrated by F. E. Naumann, and adopted as a fundamental law of the phenomena of uni-polar induction. But W. Weber, who first specially investigated the phenomena to which Faraday invited attention, disputes the sufficiency of Ampere's explanation of the rotation of a magnet on its own axis when it is traversed by a galvanic current.—*Ann. der Phys. und Chem.*

THE CANTOR LECTURES AT THE SOCIETY OF ARTS.—On Monday, April 21, the first of a series of five lectures on "Recent Advances in Telegraphy," by Mr. W. H. Preece, was read, in the compulsory absence of the author, by Mr. W. H. Kempe. The syllabus of the lectures gives the following as the topics for consideration during this lecture: Definition of Telegraphy and Electricity, Electrical Effects, Sources of Electricity, and Economical Distribution of Electrical Currents. The author commenced by dwelling upon the hypothesis that electricity is a mode of energy, and illustrated his argument by experimentally showing the effects of a current in producing light, in producing chemical decomposition, in changing the character of a piece of soft iron, and thus causing it to attract or repel certain other bodies. He described at some length the various batteries in common use, such as the Fuller, Muirhead, U. K., Gravity, Lechlanché, and Fuller's bichromate battery, stating that the Postal Telegraph Department had in use 1,650 bichromate, 2,450 U. K., 12,750 Muirhead, 500 ordinary Daniell, and 500 Lechlanché batteries. The thermo-pile was then discussed, and the effects of a laboratory Gramme shown. By means of diagrams the audience was made acquainted with the secrets of open, closed, and universal circuits. The next lecture will be given on Monday, April 28.

SPECTRAL PHENOMENA IN THE ARC PRODUCED BY A SIEMENS' MACHINE.—A Paper on this subject was recently presented to the Royal Society by Mr. J. Norman Lockyer. The following abstract will enable the reader to understand his conclusions:—"In continuation of my work on the spectra of metallic vapours photographed when incandescent in the electric arc, I have recently employed a Siemens' dynamo-electric machine driven by a gas engine of ten horse-power, using an effective force of five or six. The greatly increased length of arc obtained by these means has enabled me to observe and protograph a new set of phenomena of great beauty, and I think of the highest theoretical importance. In my former work with a battery of thirty cells, in order to obtain the lengths of the lines, it was necessary, in consequence of the shortness of the arc, to throw an image of a horizontal arc on the vertical slit of the spectroscope. In this manner perfectly symmetrical photographs were obtained, the shortest lines due to the core, and the middle portions of the longest ones proceeding both from the core and the exterior portion, lying in the axis of the photograph. With the Siemens' machine the arc is not only much longer, but when some substances are introduced into it, it is accompanied by a flame sometimes three or four inches long, of great complexity both with regard to colour and concentric envelopes. The spectrum of this flame was first photographed side by side with that of the arc itself, and when the poles are clean the flame has been shown by eye observation to be chiefly due to the oxidation of the carbon and calcium vapours which exist in the free state in the air, thus giving us absolute demonstration of a combination brought about among vapours by reduction of temperature. The various phenomena presented in these photographs, especially the greater breadth of the reversals in the case of some of the metallic lines in the flame, and the gradual introduction of new spectra, led me to imagine that in different regions *of the arc itself* the spectroscopic effects might vary greatly; and to test this I very carefully projected the image of a vertical arc on the slit, focussing that particular light which I was about to photograph. In the plates thus obtained, the spectra of those portions of the arc adjacent to the positive and negative poles are widely dissimilar. We may say, roughly, that the carbons employed give a spectrum containing the flutings of carbon and the lines of calcium, some of them reversed, as I have shown many years ago, both in the case of this and other substances. In the photographs of the arc taken under the conditions I have stated, the calcium lines cling to one pole and the carbon flutings to the other, the lines which reverse themselves in the case of calcium being those which have their intensity most pronounced close to the pole. That this is a phenomenon not dependent upon the chemical constitution of the two poles, but rather on some electrical separation, is rendered evident by the fact that on changing the direction of the current the calcium and carbon spectra change positions. Although these phenomena are very marked in the photographic region, as is evidenced by the photographs which I submit to the Society, they yet appear more strongly developed in the less refrangible regions. The exquisite carbon flutings in the yellow-green, for instance, cling more closely to the pole than those in the violet. So much for the spectrum of the poles themselves. If, now, we introduce a metal and observe its vapour, we find a perfectly new set of phenomena. We get long and short lines, but the law which they obey is no longer the one in operation when the parts of the arc examined are symmetrical with reference to the positive and negative poles as when a horizontal arc is employed. Some lines stretch across the spectrum with their intensities greatest close to one pole, while other lines invisible at this pole are most intense at the other. In one photograph, for instance, the blue line of calcium is visible at one pole, the H and K lines at the other. More than this, there is a progression of lines, so to speak, from pole to pole. They lie *en échelon* along the spectrum. In some photographs the lines are divided between the two poles, some lying at one and some at the other. In others again, only the central region is occupied in the case of some of the lines, the line being enormously distended either like a spindle or a half-spindle, with the bulging portion in some cases on the more, in others on the less, refrangible side. It is very difficult to understand what process is here at work if we are not in presence of separations brought about by temperature and electricity. However this may be, a most convenient method is afforded of separating basic from non-basic lines. I have already, in previous communications, referred to the repetition of doublets in some spectra, and of triplets in others; and it often happens that one member of a doublet or triple group is basic. The wide iron triplet near G, referred to in my communication read on the 12th December, has its central member basic with calcium; and this is most beautifully shown by the extension of the iron triplet right across the arc, while the central member alone is thickened along with the other calcium lines on one of the poles."

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LUIGI VIANISI'S REPEATER.*

By Dr. A. Tobler, of the Polytechnicum, Zürich.

Amongst the latest contrivances for duplex working is that which is described in the *Journal Télégraphique* in 1874 and 1876, by Luigi Vianisi, of Messina, and which is based on a similar system to that of Gerritt Smith, assistant electrician to the Western Union Telegraph Company, New York, viz., that of the Poggendorff Bridge. Both systems so far agree in the arrangement of the batteries that the balance is obtained in the circuit containing the one battery, and differ from one another in this respect, that Vianisi chooses as line the circuit containing the second battery, whereas Smith, on the other hand, chooses the circuit containing no battery; both suffer by the disadvantage (to be indicated by calculation) that the portion of the current entering the line issues from it proportionately weak.

Vianisi has designed as many as nine combinations of his system. One of these is that which is mentioned in *Dingler's Polytechnisches Journal*, 1877, 226, 503, and which (with No. 6) has been for some time past in operation in Italy and Switzerland. This one differs from the others in effecting the balance in the receiver of the sending station, by means of a current coming from the receiving station; therefore each station needs but one battery (a similar arrangement has been designed by Mr. G. K. Winter, telegraph engineer to the Madras Railway). When neither key is depressed, both batteries are closed, but, since similar poles are connected to the line, the currents being equal and opposite, do not produce any effect. When station I. is sending, its own battery is short-circuited through I's receiver; when both I. and II. send, each battery acts upon its own receiver, the currents passing through the line neutralising one another.

Before we look more closely into the system, it may be well for us to consider the mathematical basis of the whole, which Vianisi has omitted to add to his descriptions.

Let (Fig. 1) the opposite poles of two batteries, B_1 and B_2, whose electromotive forces are equal to E_1 and E_2, be connected by wires, and let a suitable receiver be connected at two points, a and b. Then, if the strength of the currents in the three branches be indicated by J_1, J_2, J_3, and the resistances by W_1, W_2, and W_3, we shall, according to Kirchoff's laws, obtain:

$$(1.)\quad J_1 - J_2 - J_3 = 0.$$

$$(2.)\quad E_1 = J_1 W_1 + J_3 W_3.$$

$$(3.)\quad E_2 = J_2 W_2 - J_3 W_3.$$

From these equations the following values may be deduced:—

$$J_3 = J_1 - J_2 = \frac{E_1 W_2 - E_2 W_1}{W_1 W_2 + W_2 W_3 + W_1 W_3} \quad \ldots\ldots\ldots \quad (4.)$$

$$J_1 = \frac{E_1 - J_3 W_3}{W_1} = \frac{E_1 (W_2 + W_3) + E_2 W_3}{W_1 W_2 + W_2 W_3 + W_1 W_3} = \frac{E_2 + J_3 (W_2 + W_3)}{W_2} \quad (5.)$$

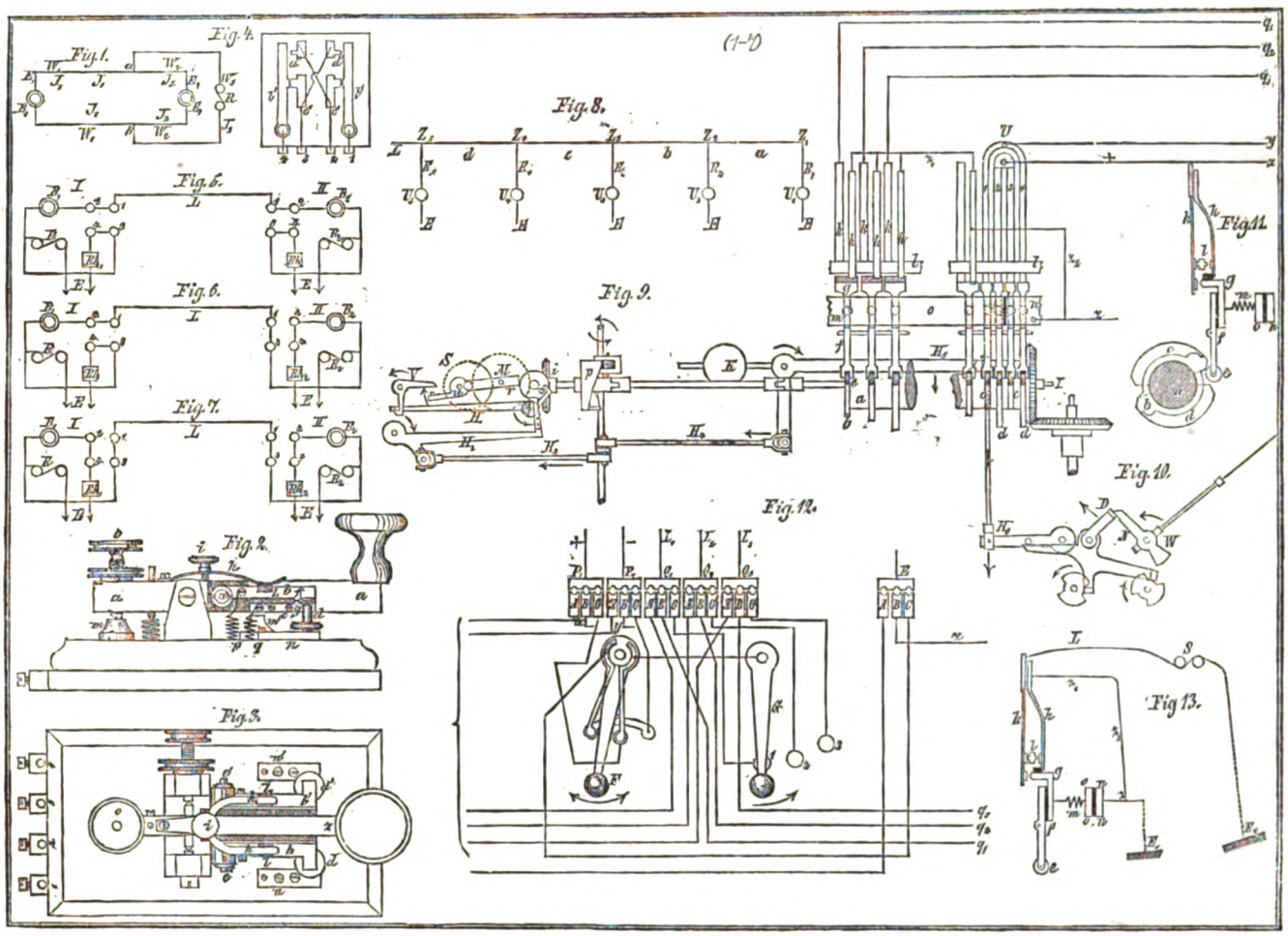
$$J_2 = \frac{E_2 + J_3 W_3}{W_2} = \frac{E_2 (W_1 + W_3) + E_1 W_3}{W_1 W_2 + W_2 W_3 + W_1 W_3} = \frac{E_1 - J_3 (W_1 + W_3)}{W_1} \quad (6.)$$

Obviously, $J_3 = 0$, if $E_1 W_2 - E_2 W_1 = 0$. . . . . (7.)

These equations, as we shall see later on, are of use when one station is sending but not receiving.

The peculiarly-constructed key which Vianisi uses, when depressed, breaks two circuits and establishes two new ones without interrupting the line. The first model of this apparatus was described by Vianisi in the *Journal Télégraphique*, 1874, Vol. 2, p. 502. Since then he has introduced some alterations. Figs. 2 and 3 represent the key as it was constructed by Hasler and Escher at Berne, and as it is in use at the Zürich Telegraph Station.

To the ordinary key-lever two auxiliary levers are added. These are insulated from the main lever by ebonite plates (marked by perpendicular lines in the figures), which are moveable around the axes e and e'. In a state of rest, the auxiliary levers by the forked spring k, k_1 (which may be tightened at pleasure by means of a screw i) are pressed upon the insulated contact-pieces (c and c'). The arms (k, k_1) of the spring are not in metallic contact with the auxiliary levers, and they press against the plates of ebonite (l, l_1). The metal plates n and n' are screwed firmly to the bottom of the apparatus below the auxiliary levers, and they have attached to them literally-disguisable moveable contact-pins (pegs). If, now, we press down the key, the auxiliary levers b and b' come into contact with the studs d, d'; and if the pressure on the key be continued, they are raised finally off the points of contact c and c'. If the key be allowed to rise again, then b



* Translated from *Dingler's Polytechnic Journal*.

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and b' come into contact with c and c', and then only do b and b' break contact with d and d'.

The connection of the binding screws 1 to 4 becomes clear from Fig. 4. In a state of rest the terminals 1 and 2 are in metallic connection by b and c; also the terminals 3 and 4 by b' and c'. When the key is depressed, a current entering at 1 flows to 3 by b, d, and c', and a current entering at 2 flows to 4 through c, d', and b'. During the motion of the key no interruption occurs, as the connections b, d and b', d' are established before the contacts between b, c and b', c' are removed; except, indeed, a momentary short-circuiting of the battery.

The adjustment of the apparatus is simple. The studs d and d' should be equal in height. When the key is in use, great care must be taken not to injure the thin spiral wires p and q (Fig. 2), which establish the connection between the auxiliary levers and contact-pieces with the binding screws. This connection is the weakest part of the whole arrangement.

In the plans of the currents (Figs. 5 to 7) the key is indicated only by the four terminals connected in pairs. The rheostats Rh (constructed in accordance with the principle of Eisenlohr's resistance-column) allow an insertion of from 1 to 4,000 S.U. The receivers R, R' are Morse ink-writers, with moveable electro-magnet and double springs (*cf. Zeitschrift des deutsch-österreichischen Telegraphenvereines*, 1865, Vol. 12, p. 22), such as have been in use for many years past on the Swiss lines. The battery consists of a modification of Meidinger elements.

1. *Both keys in a state of rest.*—At each station 1 and 2, 3 and 4 are connected; both batteries B have copper to line, with zinc through receiver and resistance to earth. As the two opposite currents are both of equal strength, the line (supposed to be completely insulated) is absolutely free from a current.

2. *Key at Station II. pressed down, at Station I. at rest* (Fig. 6).—At II. the points 1 and 3, 2 and 4 are connected; at I., as before, 1 with 2, and 3 with 4. The positive current of battery B_1 goes through line L to II., flows through two parallel branches through the receiver R_2, the resistance, and returns through earth to I. through the parallel branches Rh_1 and Rh_2. But the receiver of the sending station II. is influenced at the same time by its own battery, the positive current from which enters from below through Rh_2 into the Morse R_2; thus a balance of the two opposite currents may be affected in R_2. On closer observation the plan in Fig. 6 appears to be identical with Fig. 1; W_1 is represented by the combined resistance of line L, of battery B_1, of the branches R_1 and Rh_1, and of the earth; W_2 by B_2 and resistance Rh_2; and W_3 corresponds with the resistance of the writing instrument R_2 of the sending station. If now we could make $W_1 = W_2$ (E_1 is henceforward taken as equal to E_2), then, according to equation 7, the receiver R_2 would remain entirely free from a current. This is not, however, always the case, as we shall see later on; more often a weak current passes through the Morse instrument of the single-sending station, and this current is not able to attract the armature.

3. *Both keys pressed down.*—At both stations the points 1 and 3, 2 and 4 are connected. The + current passes in both stations through rheostat and receiver to the zinc pole. The zinc pole of both batteries is, moreover, connected to line; the currents neutralise, therefore, each another in the line.

Let us now choose a practical example, in order to see whether any difference exists between the single and duplex signals.

Let the resistance of the line be taken as equal to 1,200 S.U., that of the receiver as equal to 400 S.U., and let the resistance in each rheostat be 1,600 S.U. (= line + receiver) be inserted. (Resistance of the earth = 0.) At each station are placed 18 Meidinger cells (E.M.F. of one cell = 1, resistance = 6 S.U.), whose combined E.M.F. = 18, and whose joint resistance = 108 S.U.

In case 2 we have, according to equations 4 to 6:—

$$W_1 = 1200 + 108 + \frac{400 \times 1600}{400 + 1600} = 1628.$$

$$W_2 = 1600 + 108 = 1708.$$

$$W_3 = 400.$$

$$J_3 = \frac{18 \times 1708 - 18 \times 1628}{1628 \times 1708 + 1708 \times 400 + 1628 \times 400} = 0{\cdot}00035.$$

$$J_1 = \frac{18 + 0{\cdot}00035\,(1708 + 400)}{1708} = 0{\cdot}0109.$$

$$J_2 = \frac{18 - 0{\cdot}00035\,(1628 + 400)}{1628} = 0{\cdot}0106$$

As the rheostat Rh_1 is arranged as a shunt to the receiver, only $\frac{4}{5}$ths of the current pass through the receiver, and $\frac{1}{5}$th through the rheostat (the ratio of the resistances of both parallel branches being as 1 : 4); from this we get—

$$\tfrac{4}{5} J_1 = \tfrac{4}{5} \times 0{\cdot}0109 = 0{\cdot}0087.$$

Let the magnetic moment of the receiving magnet be equal to the strength of current multiplied by the square root of the magnet's resistance (*vide* Wiedenbach, *Compendium der Telegraphie*, Wiesbaden, 1877), then we have

$$M_1 = \tfrac{4}{5} J_1 \sqrt{W_3} = 0{\cdot}0087 \times 20 = 0{\cdot}1740.$$

The receiver of the sending station receives a magnetic moment $20\,J_3$ or 0·00700, which is entirely incapable of producing any effect.

In case No. 3 we have for each station

$$J = \frac{18}{1600 + 400 + 108} = 0{\cdot}0085;$$

$$M_3 = 0{\cdot}0085 \sqrt{400} = 0{\cdot}1700.$$

The difference of the magnetic *moments* in cases 2 an 3 has the very good result $D = 0{\cdot}004$. Therefore the single and duplex signals are almost of equal strength.

In Vianisi's first arrangement (*Journal Télégraphique*, 1876, Vol. 3, p. 234) the terminals 3 and 4 were insulated when the key was at rest; therefore the current acted with full force on the receiver at I., since the shunt r did not exist. The consequence was that W_1 could be made equal to W_2, and therefore the current J_3 and magnetic moment in $R^1 = 0$.

If we pursue the calculation with the numerical values given above, in case 2 we find the magnetic moment of the receiver R_1

$$M_1 = 0{\cdot}2100.$$

In case 3 we have, of course, as above, $M_3 = 0{\cdot}1700$, and thus $D_1 = 0{\cdot}04$; that is, considerably greater than in the preceding instance. Too sensitive receivers will not work with certainty under these circumstances, as the experiments made by Vianisi on the line from Messina to Catania, and on that from Messina to Palermo, have shown.

The difference between the simple and duplex signals in our first example may be still more reduced by inserting a resistance coil of 40 S.U. at each station between the terminal 1 and the line, we find then for case No. 2,

$$J_3 = 0,$$

$$J_1 = J_2 = 0{\cdot}0105,$$

$$M_1 = \tfrac{4}{5} J_1 \sqrt{W_3} = 0{\cdot}1680;$$

for case No. 3, as above stated,

$$M_3 = 0{\cdot}1700,\ D_2 = 0{\cdot}002.$$

It may be mentioned that it is the usual practice to insert a small galvanometer (detector) between the receiver and the earth. The resistance of it (in our country only 2·5 S.U.) has to be taken into consideration in the numerical examples.

The receiver of the sending station shows a certain inertia. In order to experiment upon this, I made an arrangement as in Fig. 1. The receiver was—1st. A relay magnet constructed by Dr. Hipp, of Neuchâtel. 2nd. A Siemens polarised relay. 3rd. A Hughes instrument. In order to make R work, the following alterations of W_1 were necessary (W_1 and W_2 were originally rheostats of 500 S.U. each):—1st. $W_1 = 320$ S.U. 2nd. $W_1 = 360$ S.U. 3rd. $W_1 = 460$ S.U. But in the last case the Hughes magnet was adjusted to a sensitiveness which would hardly suit in practice.

The above-described duplex method may be applied also to the Hughes instrument. Vianisi proposes, for this purpose, his répétiteur automatique (intended expressly for transmission), a relay whose contact lever, like the above-mentioned key, at once interrupts two currents and establishes two new ones (*Journal Télégraphique*, 1876, Vol. 3, p. 254). It is then inserted in the local circuit of the sending Hughes. I think, however, that it does not need this auxiliary apparatus. The mechanical locking of the printing axis applied to the new Hughes telegraphs affords a means for directly adapting Vianisi's method to the Hughes. With this end in view, we have to apply to the contact-lever of the sending Hughes a system of auxiliary levers, as in Figs. 2 and 3. Of course, the moveable parts b, b' must be worked proportionately more easily. The plan of the insertion then differs in no respect from that in Figs. 4 to 6. Under R we have to bear in mind the rolling of the receiving Hughes, under 1 to 4 the mechanism of the contact with the sending Hughes.

In the excellent works of Weidenbach already mentioned there occurs a numerical example of the bridge method as modified and applied to the Hughes, by Messrs. Grimmert and Canter. We will now, for the sake of more exact comparison, take these numbers for our example.

Resistance of line, 80 Rh; of one Hughes, 20 Rh; of one element, 0·12 Rh (all the resistances are expressed in rheostat-units, each equal to 50 S.U.). The strength of current required to work a Hughes is 0·73. Weidenbach mentions further that, under the same circumstances, 80 to 96 elements are requisite for

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single working. Now, if we take 100 elements for the sake of experiment, we get the following. In case 2:—

$$J_3 = \frac{100 \times 112 - 100 \times 108{\cdot}6}{112 \times 108{\cdot}6 + 112 \times 20 + 108{\cdot}6 \times 20} = 0{\cdot}0205.$$

$$J_1 = \frac{100 + 0{\cdot}0205\,(112 + 20)}{112} = 0{\cdot}917.$$

$$J_2 = \frac{100 - 0{\cdot}0205\,(108{\cdot}6 + 20)}{108{\cdot}6} = 0{\cdot}8965.$$

Since, just as in the first example, the rheostat forms a shunt to the Hughes magnet, $\frac{5}{6}$ J will flow through the coils (or $\frac{5}{6} \times 0{\cdot}917$; that is, 0·764). But the moment the armature of the receiving Hughes strikes the locking lever, the coils are short-circuited, and the values just obtained are altered, *i.e.*:

$$J_3 = \frac{100{\cdot}112 - 100{\cdot}92}{112 \times 92 + 112 \times 20 + 92 \times 20} = 0{\cdot}139.$$

$$J_1 = \frac{100 + 0{\cdot}139\,(112 + 20)}{112} = 1{\cdot}056.$$

$$J_2 = \frac{100 - 0{\cdot}139\,(92 + 20)}{92} = 0{\cdot}917.$$

The current J_3, which flows through the receiving Hughes of the sending station, evidently strengthens the induced magnetism of the cores, since it flows in a direction opposite to that which produces the signals at II. If, now, station I. begins to send a sudden reversal takes place in the magnet at station II. An experimental investigation of these facts seemed interesting to me, for it might be apprehended that the magnet would show a certain inertia. I connected a Hughes with two batteries and two rheostats, as shown in Fig. 1; between P and P' a key was inserted whose depression suddenly broke the circuit of the battery P. Having first made $W_1 = W_2$, I gradually diminished W_1, which had the effect of strengthening the cores in R, and suddenly depressed the key, then the magnet was solely acted on by P'. When the magnet was properly adjusted, the locking of the printing axis was effected without the slightest delay or trouble.

In case No. 3 the current acting on each Hughes is

$$J = \frac{100}{100 + 20 + 12} = 0{\cdot}757,$$

and the difference of currents in cases No. 2 and No. 3 = 0·007.

J_3 could be made = 0, by a proceeding which has been mentioned before, *i.e.*, by the insertion of a resistance coil between 1 and the line.

In the example given by Mr. Weidenbach there are no less than 333 elements required to obtain a current J = 0·73. But it must be remembered that the bridge method may be applied to Hughes instruments of old and modern construction, and that no auxiliary mechanism need be added.

Mr. Vianisi has also indicated a method of duplex translation, and sundry dispositions to avoid the bad effect of the discharge, as occurs on lines of greater length. They are to be found in the *Journal Télégraphique*, 1876, but it is not my intention to give a criticism of them, as it would unduly lengthen my Paper.

[A translation of another Paper from *Ding. Polytechnic Journal* is crowded out of this issue. Figs. 7—13 on the plate refer to it.—Ed. *E.*]

LITERATURE.

THE TELEGRAPH IN AMERICA.

The Telegraph in America: Its Founders, Promoters, and Noted Men. By James D. Reid. [Derby Brothers, New York, 1879.]

SECOND NOTICE.

"MORSE."—How many of us ever think of the pioneer in modern telegraphy when we meet with the word in our reading, or hear it uttered by a neighbouring operator? Too few know the long labour, the trials, the sufferings, and the successes of the inventor of the telegraphic alphabet, and of the ordinary instrument bearing this name. Mr. Reid has given us a brief, yet complete, history of the man and his work, written in a style that emphasises the love of a disciple to the master. We cannot hope to do more than give a faint idea of the veneration shown by the writer towards Professor Morse, for nothing less than the whole of the chapters devoted to the subject would fill in and complete the picture. He tells us that Samuel Finley Breese Morse was born of worthy parents on April 27, 1791, at Charlestown, Mass. At the age of four, Professor Morse commenced his education, like some other men of our acquaintance, under the roof of a venerable dame whose ideas of education were not altogether in accordance with those of schoolmasters of the more modern school. At the age of seven, young Morse was promoted to a preparatory school. At fourteen he entered the freshman class of Yale College. The author is anxious to show that the student here made himself thoroughly acquainted with electrical science as then known by attending the classes of Professors Day and Silliman, and some years after he renewed his studies under Professor Dana, of New York, and Professor Renwick, of Columbia College.

Morse resolved to devote himself to painting. "He found," says our author, "in painting, an inspiration, he selected it as his chosen profession." He studied under Allston, and accompanied his master to Europe. Benjamin West became "his friend and father." He exhibited in 1813 in the Royal Academy. Poverty, however, was as close to the side of genius as it usually is. The year 1815 saw the "clothes of Morse threadbare, and his shoes out at the toes." He returned to Boston. Painting failed to bring bread and cheese, and a trial was made of invention. In concert with his young brother, he made an improvement upon the force pump. Fancy a pump to bring renown, to fill empty pockets, and more, to pave the way to the marriage state. The professor was rather anxious to become a Benedict; but the pumps would not go pecuniarily. He commenced to paint portraits, and was fairly successful. We must pass over the foundation of the National Academy in New York, and subsequently, his sojourn at New Haven. In 1829 he again visited Europe, and after three years of travel sailed on October 1, 1832, from Havre for New York, in the packet ship, Sully. Dr. Jackson of Boston was on board the vessel, and introduced discussions on electrical subjects, and explained an electro-magnet he had amongst his luggage. This led one of the company to inquire "if the velocity of the electricity was retarded by the length of wire." Dr. Jackson replied that electricity passed instantaneously over any known length of wire. At this point Mr. Morse, remembering the lesson of his instructor at Yale, remarked, "If the presence of electricity can be made visible in any part of the circuit I see no reason why intelligence may not be transmitted instantaneously by electricity." The work had come, the question was given, the solution was to be found. It was given in the Morse alphabet and the Morse instrument. Imperfect as were the first conceptions, gradually the whole grew clear. Poverty stood in the way of experiment and an early realisation of his hopes. Mr. Reid gives a graphic description of the early designs, and illustrates his text by some very good wood-cuts; and to the book, therefore, we refer the reader for these details. The thoughts on the Sully in 1832 were tested in 1835. Thus we read, p. 83:—"The first completed instrument for recording was first tested in 1835. It resembled in external appearance a small melodeon, having a keyboard on which were the letters, figures, periods, commas, &c." This period was one of intense trial to the poor inventor. He was refused a patent in England. The author tells us (page 91) that "the Attorney-General would not examine the apparatus" to see if it really was different from that of Cooke, generally but erroneously attributed to Wheatstone. It was not till 1843 that Morse commenced to reap his reward. Congress supported him to the tune of $30,000, and from this time the telegraph progressed. The dawn had come, the victory was won, and though the labour was far from being over, there was no more doubt. "On April 1, 1845, the line, which had been worked as a curiosity, was opened for public business. The operators appointed were Mr. Vail at Washington and Mr. Henry J. Rogers at Baltimore." What matters it if the first four days' work only realised one cent. The telegraph had become a public institution in America, and was destined soon to realise far more than its most sanguine supporters at that time dreamt. These early trials, the disappointments, the difficulties, the successes, are they not recorded in the volume before us? To it, then, we refer those who are interested to know more of the early pioneers, their character, and their labours. There they can read about and see portrayed in order Kendall, Swain, Caton, Tillotson, Wood, Dakers, Leffects, and many others, such as Orton, Phelps, Gray, Eckert, and Bentley. The vast amount of information given in this huge volume is too much for us to recapitulate in our columns. There is hardly a page but contains something new to the English reader, and we trust the book may find a welcome nook in many an electrical library.

[We are compelled to leave over for our next issue several interesting communications, including letters from Mr. R. E. Baynes, in reply to Mr. Cumming; from Mr. R. S. Brough, on a criticism of Mr. Schwendler's work; from Dr. A. Muirhead, in reply to Mr. R. S. Brough, on the "Split Battery Method"; from Mr. J. T. Sprague, on "Electrostatic Potential"; and from "Sam Slick," &c.—Ed. *E.*]

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THE CANTOR LECTURES.

Nine thousand pounds is a large sum of money to most people, and it is not often that a bequest to that amount falls into the hands of a scientific institution. The Society of Arts, however, does not wholly devote itself to the consideration of pure science, but chiefly, perhaps, to that of applied science; so that the bequest of a moiety of the above-named sum to that institution was certain to aid directly or indirectly the advancement of knowledge. On the 3rd March, 1859, Mr. T. E. Cantor, M.D., a member of the India Medical Service, died, and it was found that he had left something over £9,000 to be divided equally between the Society of Arts and Wellington College. The mere bequest was a great gain to these institutions, but we think it was made still greater by the unrestricted manner in which it was given. Men and manners change. The wants of one age are not those of another, and hard and fast rules, as has been seen by many recent legislative enactments, are not to be borne by a nation advancing by rapid strides towards adolescence. The money left by Dr. Cantor was to be applied as the Governors of the College and the President of the Society deemed most conducive to the promotion of the objects of the College and of the Society.

In 1863 the Society of Arts received £5,042 as its share of the bequest, and the amount was invested in India Securities, bearing probably on the average not less than five per cent. After making provision for the mother-in-law (we speak from memory and subject to correction) then living at Copenhagen, who had been partially dependent on Dr. Cantor, the council of the society determined to use the interest of the money in giving annual lectures relating to internal commerce, chemistry as applied to manufacture, and industrial art. The cost of these lectures was estimated at £150, and it was thought the balance might advantageously be spent in adding to the library.

We have thus given briefly the history of the rise of the Cantor Lectures, but it is far from our object to continue that history except so far as it concerns us as "electricians." We have, however, no hesitation in saying that many of the series of lectures have become classical. All have been printed in the Journal of the Society, and many have been reprinted, and can be had in pamphlet form. The one series of lectures most interesting to us has not, we believe, been reprinted by the Society.

In 1866 Professor Fleeming Jenkin, F.R.S., delivered the second course of Cantor Lectures for that year on the subject of "Submarine Telegraphy." At that period of telegraphic history these lectures undoubtedly formed the best connected essay on cable work that existed, and they have formed the basis upon which more recent writers have amplified and written. Professor Fleeming Jenkin was one of the pioneers in submarine cable work. He had, in conjunction with Sir W. Thomson, devoted some years of arduous labour, mental and physical, to the questions connected with the laying of deep-sea cables. He formed one of that small band who, undaunted by failure, had, with renewed energy, steadily grappled with difficulty after difficulty till success was achieved. His great experience pointed him out as one of the best lecturers that could be obtained, and his lectures did not falsify that opinion.

Since the year 1866 the progress of telegraphy has most unaccountably been overlooked by the Society, and till this year the subject has been sought for in vain among the Cantor Lectures. The present writer mentioned the fact to the late Secretary of the Society, and was gratified to find a wish expressed in a casual conversation so soon realised. Among the lectures announced for 1879 was a series on "Recent Advances in Telegraphy," the first of which was delivered on Monday, April 21st. The lecturer is Mr. W. H. Preece, who was unavoidably absent at the first lecture, which was read for him by Mr. Kempe. If we are correctly advised, Mr. Preece was absent on "cable work," having to superintend the repair of the cable across the Humber. The remaining lectures will be given on four successive Monday evenings, and, we have no doubt, will be well attended. The programme

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of the lectures indicates that we may expect some interesting information on subjects connected with telegraphy, which are not yet generally understood. It is surprising to find, for example, how ignorant are men, usually well informed, upon the methods of duplex and quadruplex working. These subjects, among others, are mentioned for consideration on May 12.

Such lectures as these are extremely useful, not only because they direct the student's attention into certain channels, but that they bring the work of science into contrast with the ordinary commercial life of Englishmen. The mind of the million is gradually acquiring a faint conception of the fact that to Science is owing a meed of thanks for ameliorating the condition of mankind. It may almost be said that the progress of civilisation is exactly proportional to that of Science. The more we consider these facts, the more we wonder at the terrible supineness and narrow scholastism of those who have in their hands the training of the next generation. We trust that before Mr. Preece concludes this series of Cantor Lectures he will think over the bearing of science on education, and try to awaken the minds of his audience to realise truly the exact position in which we are now standing. If lectures, isolated by an interval of fifteen years, are valued, how much more would be a constant and systematic training, so that the possibilities of science might be better understood, and more minds induced to attack the unlimited but important problems now awaiting solution.

CORRESPONDENCE.

POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There is no more satisfactory evidence of the progress of a science than when its cultivators, having settled all their differences about the connexion of the phenomena, proceed to reconstruct the definitions. Even in the most mature sciences, such as geometry and dynamics, the study of the definitions still leads original thinkers into new regions of investigation; and in a science like that of electricity, the growth of which has proceeded from so many different centres, it is only to be expected that when the different departments have grown till they meet, their definitions will need some adjustment in order to make them consistent with each other.

Thus, if we were to restrict our attention to electrostatics, it might be convenient to use the phrase "potential-difference," as Mr. Baynes suggests, instead of the ordinary phrase, "electromotive force," but in other parts of electrical science we have to deal with electromotive force in cases where potential, and, therefore, potential-difference, are words without meaning.

I therefore prefer to introduce the definition of electromotive force somewhat early, and in the following double form:—

1. Whatever produces or tends to produce a transfer of electricity is called Electromotive Force.

2. The Electromotive Force from A to B, along the path A B, is measured by the quantity of work which must be done by an external agent *per* unit of electricity transferred from B to A along the path B A; the quantity of electricity actually transferred being supposed to be infinitely small, because, in general, the transference of a finite quantity of electricity alters the value of the electromotive force.

The statement (1) is not an explanation of what electromotive force *is*. The man who propounds such a definition ought first to tell us what electricity *is*. All that we attempt is to enable the student to distinguish his concept of electromotive force from his other electrical concepts. It is modelled on the lines of the familiar definition of mechanical force, and those who find that they understand mechanical force better by "feeling what it is like" can easily apply the same method to the study of electromotive force.

It will be observed that in statement (2), which defines the *measure* of electromotive force, it is not the electromotive force from A to B in general which is defined, but that along a definite path A B. For purposes of elementary illustration, we may suppose the path to be marked out by a wire, but after we have become familiar with the properties of dielectrics we may include the case in which the path passes through a dielectric, remembering that since in this case the electromotive force depends on the quantity of electricity already displaced, we must stipulate that the quantity of electricity displaced in the process for measuring the electromotive force must be infinitely small.

Whenever the electricity in every part of the field is in equilibrium, the electromotive force from A to B is the same along every path which can be drawn from A to B. We may therefore take any point Z as a point of reference, and define the potential of any other point A as the electromotive force from A to Z. In this case the electromotive force from A to B will be the excess of the potential at A above the potential at B, and all the electromotive forces in the system may be expressed in terms of the potentials of the different points of the system.

The theory of electrostatics is greatly simplified by the introduction of this new concept of potential. Instead of having to think of the electromotive forces between every pair of points, along all possible paths between these points, we have now only to think of each point as having its own potential with respect to a certain point of reference, which we have called Z.

The student, however, who wishes to acquire a more intimate knowledge of potential by "feeling what it is like" will be disappointed. In studying hydrostatics and thermodynamics he may experience something of pressure by going down in a diving-bell, and something of temperature by visiting a Turkish bath; but if he repeats Faraday's experiment, and lives in a small laboratory with conducting walls, supported on glass legs, he and all his electrometers may be electrified together to any potential, and neither he nor they will be in any way affected.

Potential, in fact, is a *relative* term, the value of which can be expressed only by arbitrary definition, just as terrestrial longitude can be expressed only with reference to some arbitrarily-chosen meridian, such as that of Greenwich or Paris.

It is true that mathematicians usually define the potential so as to make it become zero at an infinite distance from all electrified bodies, and this definition makes the integral simpler by leaving out the arbitrary constant of integration. The mathematicians, therefore, place the point of reference, Z, at an infinite distance. It is found, however, by practical electricians that this point of reference is not conveniently accessible. They, therefore, prefer to select the potential of the earth as a zero common to all terrestrial electricians; but when the whole apparatus of an experiment is under the control of a single electrician he is at liberty, as an electrician, to "make his own earth."

But as soon as we pass from electrostatics to other departments of electrical science we find that the concept of potential is no longer available, except when used in a restricted sense and under carefully defined conditions.

For if a current is flowing round the circuit A B C A, the electromotive force from A to C along the path A B C must be greater than that along the direct path A C, so that, if the potential at C were given, that at A would have a value depending on the path by which we suppose A connected with C.

If we wish to find the potential of a particular part of an electro-magnetic instrument, say, an induction coil, during a given phase of its action, and if for this purpose we connect that part of the instrument with the electrode of an electrometer by means of a wire, the indication of the electrometer will be perfectly definite as long as the position of the wire is definite, but it will in general depend on the path marked out by the wire. Thus, if part of the wire is wound round the magnet of the induction coil the electrometer indication will be different from what it would be if the wire went to the electrometer in a straight line.

In a case like this, in which the electromotive force from A to B can be varied in a continuous manner by a continuous variation of the form of the path A B, the term potential is absolutely without meaning. In mathematical language it might be described as the integral of a differential expression which cannot be integrated.

There are other cases, however, in which the electromotive force from A to B is the same for all paths into which a given path A B can be transformed by continuous displacement without cutting a given closed curve.

Thus in cases in which there is a steady current, as in a voltaic or thermoelectric circuit, there are certain surfaces of contact in which two different media meet, and these surfaces are bounded by closed curves in which three media meet.

If the path A B is moved about in any manner, but so that it never cuts through any of these closed curves, the electromotive force from A to B will remain the same, but if it is made to cut through one of the closed curves, the order of the media through which it passes will be changed, and the electromotive force will differ by a finite quantity from what it was before, but will con-

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tinue the same during the subsequent motion of the path AB till the next time that it cuts through one of the closed curves.

What I have just stated in terms of the path AB and the closed curves can be stated more simply in terms of the finite regions occupied by the different media.

In the first medium let the electromotive force from any point A_1 to a point of reference Z_1, along a path $A_1 Z_1$, entirely within the first medium, be called the potential in the first medium, and let the same be done for the other media, assuming a different point of reference for each.

This being done, consider a point on the surface of contact of the first medium with the second. The potential at a point in the first medium will exceed the potential at a contiguous point in the second medium by a quantity (positive or negative), which is found to be constant, and the absolute value of which depends on the positions arbitrarily chosen for Z_1 and Z_2. Let us call this quantity the electromotive force of contact from the second medium to the first.

In a voltaic circuit, the sum of the electromotive forces from zinc to the electrolyte, from the electrolyte to copper, and from copper to zinc, is not zero, but is what is called the electromotive force of the circuit—a measurable quantity. Of these three electromotive forces, only one can be separately measured by a legitimate process, that, namely, from copper to zinc.

If we cause an electric current to pass from copper to zinc, the heat generated in the conductor per unit of electricity is a measure of the work done by the current per unit of electricity, for no chemical or other change is effected. Part of this heat arises from the work done in overcoming ordinary resistance within the copper and the zinc. This part may be diminished indefinitely by letting the electricity pass very slowly. The remainder of the heat arises from the work done in overcoming the electromotive force from the zinc to the copper, and the amount of this heat per unit of electricity is a measure of this electromotive force.

Now, it is found by thermoelectric experiments that this electromotive force is exceedingly small at ordinary temperatures, being less than a microvolt, and that it is from zinc to copper.

Hence the statement deduced from experiments in which air is the third medium, that the electromotive force from copper to zinc is 0·75 volts, cannot be correct. In fact, what is really measured is the difference between the potential in air near the surface of copper, and the potential in air near the surface of zinc, the zinc and copper being in contact. The number 0·75 is therefore the electromotive force, in volts, of the circuit copper, zinc, air, copper, and is the sum of three electromotive forces, one only of which has as yet been measured.

It is true that Messrs. Ayrton and Perry in their Paper on "The Contact Theory of Voltaic Action" (Proc. R. S., March 21, 1878), make the following statement:—

"In fact we have good reason to believe that there is no great difference of potential between a metallic or liquid surface, and the air in contact with it."

A statement like this, coming from men whose scientific energy is threatening to displace the centre of electrical development, and to carry it quite out of Europe and America to a point much nearer to Japan, is worthy of all attention, even without an explicit statement of their "good reason."

But Mr. J. Brown has shown (*Phil. Mag.*, Aug. 1878, p. 142), by the divided ring method of Sir W. Thomson, that whereas copper is negative with respect to iron in air, it is positive with respect to iron in hydrogen-sulphide.

It would appear, therefore, that the reason why the results of the comparison of metal by the ordinary "contact force" experiments harmonise so well with the comparison by dipping both metals in water or an oxidizing electrolyte is not because the electromotive force between a metal and a gas or an electrolyte is small, but because the properties of air agree, to a certain extent, with those of oxidizing electrolytes. For, if the active component of the electrolyte is sulphur, the results are quite different, and the same kind of difference occurs when hydrogen-sulphide is substituted for air.

We know so little about the nature of the ions as they exist in an electrolyte that, even if we could measure the quantity of heat generated or absorbed when unit of electricity passes from a metal to an electrolyte, or from an electrolyte to a metal, we could not determine from this the value of the electromotive force from the metal to the electrolyte.

If this is the case with liquid electrolytes, we have still less hope of determining the electromotive force from a metal to a gas, for we cannot produce a current from the one to the other without tumultuary and non-reversible effects, such as disintegration of the metal and violent disturbance of the gas by the discontinuous discharge.

To return to the question of terminology. I have not ventured to disuse the old phrase, electromotive force, the use of which has done more to render definite the ideas of practical electricians than any other word in the electrical vocabulary.

Under certain conditions, which are satisfied in electrostatics, the electromotive force from A to B may be expressed as the excess of the potential at A above that at B.

The word Potential is used in a quite different sense by Prof. Clausius in his book entitled "Die Potentialfunction und das Potential." What we have called Potential, Clausius calls Potentialfunction, the point of reference being understood to be at an infinite distance from all electrified bodies. That which English writers call the Potential Energy of a system, that is to say, the work required to bring it from a standard state at rest into a given state at rest, Clausius calls, in general, *Ergal*, but in the particular case in which the force between two particles is inversely as the square of the distance, and the standard state is that in which all the particles are removed to infinite distances from each other, he gives the *Ergal* the special name of Potential.

What is sometimes called "electric force at a point" may be defined as "electromotive force per unit of length," measured in a given direction. After some consideration, I have thought it advisable to use the word "intensity" for concepts of this kind, such as the rate of acceleration of heavy bodies, which I would call the "intensity of gravity." Similarly, I would call the "resultant electric force at a point per unit of electricity" the "electromotive intensity at that point."

The word *Scheidungskraft* indicates well enough what is meant, but I have made no effort to naturalise a word which seems to suggest the two-fluid theory exclusively.

The word Tension, in English, means that kind of stress which arises from stretching. It is seldom applied to anything but longitudinal tension, whereas its opposite, pressure, is often applied to tangential and isotropic stress.

In French, however, and in some books translated from that language, the word *tension* is often used for isotropic pressure, such as that of steam, &c., which in good English is always called pressure; and it is also used to express, somewhat vaguely, the tendency which electricity has to escape from a body, without any distinct idea of where it wants to go to. We know that this has something to do with potential, but it would be asserting far too much to say that whenever the word *tension* occurs the author means neither more nor less than potential.—Yours, &c.,

J. CLERK MAXWELL.

"THE NEW THEORY OF TERRESTRIAL MAGNETISM."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The difficulty experienced by Mr. Laister and others in comprehending the new explanation of terrestrial magnetism recently advanced by Professor Perry and myself is well summed up in the conclusion of the letter written by Mr. Laister and given in *The Electrician* of the 19th instant. He says, "The statically-charged felloe of a revolving wheel would magnetise the axle, but would not, we imagine, magnetise the nave or the spokes or the intervals between them. And what is true of a wheel would be true of a globe."

Since Mr. Laister admits that the axle which is at rest would be magnetised, but thinks not the revolving nave of the wheel, it follows that he concludes the *revolution* of the nave *itself* must induce in it an equal and opposite quantity of magnetism to that which would be induced in it if the nave were also at rest while the electrified felloe was revolving. This is equivalent to saying that, assuming we could disconnect the felloe from the nave, then if the electrified felloe were at rest and the nave only revolving the nave would be magnetised. But in order to compare the nave with the iron inside the earth we must, of course, assume it totally without electric charge. Revolving, therefore, about its own axis, a totally *un*electrified body in a *non*-magnetic field would, according to Mr. Laister, magnetise it. Now, not only is there no experiment to prove this result, but I venture to suggest that it is a highly improbable one. Consequently we have every reason for assuming that the *mere* revolution of a totally *unelectrified* body produces *no* magnetic field. Whether, therefore, the nave of the wheel were at rest while the electrified felloe were revolving, or revolving together with the felloe, it would be equally magnetised, and similarly for the remainder of the wheel as far as the rotation of any particle about its own axis. But the motion of *every* particle in a revolving rigid sphere consists of a rotation round the axis of the sphere combined with a rotation round its own axis. And we have settled that the rotation of an *un*electrified particle round its own axis cannot alter its susceptibility of receiving magnetic induction. The total action, therefore, of a revolving electrified sphere on the interior will be exactly the same as if the rotation of the particles round their own axes did not exist, that is as if the motion were what is commonly called "sun and planet motion," similar to that of the bobbins in the

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machinery used in sheathing telegraph cables to prevent the iron wire receiving a torsional strain as it is lapped on the core. We have, therefore, in any calculations of the electro-magnetic field produced at any point by the rotation of all the electrified particles on the earth's surface to consider only the various linear velocities round the earth's axis.

But perhaps Mr. Laister may remark, if the mere rotation of an *unelectrified* body produces no magnetic field, so also will any motion of an *unelectrified* body; hence, that the motion of the unelectrified parts of the earth round its axis cannot in any way alter the electro-magnetic potential produced inside by the rotation of the electrified surface; or, in other words, that there was no necessity for Mr. Perry and myself in the solution of this problem to consider the *relative* motion of the surface to the interior, but only the *absolute* motion of the surface. Now, this is precisely what has been suggested to me by Mr. G. F. Fitzgerald, of Trinity College, Dublin, since the reading of the paper. He, following up our idea, has put forward the possibility that a mass of iron would become magnetised by a static charge of electricity, if both had rapid motion in the same direction in parallel lines and with exactly the same velocity; in fact, that *relative* motion is unnecessary for the mechanical production of an electro-magnetic field. If this proposition (which has not yet been put to an experimental test) be true, then not only would the mathematical analysis required in the investigation of our theory of terrestrial magnetism be much simplified, but the charge of electricity on the earth's surface necessary to produce its magnetic moment would be even less than that given in our paper, as it will appear shortly in the *Philosophical Magazine*. I hope to try this idea of Mr. Fitzgerald's experimentally in a short time, but at present I do not propose giving any further indication of the reasoning employed in arriving at his conclusion, or of the way our equations would be simplified by using it, preferring to leave the investigation in the rigid form as it now stands rather than to introduce any idea which might be regarded as problematical, even although such an introduction would both add weight to the new theory, and might, perhaps, explain from the unequal velocity in *space* of the same place on the earth's surface at mid-day and midnight the cause of the solar diurnal magnetic variations.

It will be seen from the above that I regard the supposed *reductio ad absurdum* conclusion recently put forward in the *Engineering*, which was that "if Professors Perry and Ayrton's theory were true, an electrified bar of iron in rapid rotation would become magnetic," very much as the supporters of Newton's principles might have regarded the taunts that the objectors to the first law of motion made when they said, "Why, if that law were true, a stone thrown up in a sailing ship ought to return to one's hand again;" or, as Sir William Thomson must have regarded the scoffing newspaper criticism, made in the days of the 1857 cable, on his theory of the retardation of signals, and which consisted in the supposed quenching, but, unfortunately for the reviewer's foresight, extremely prophetic remark, "Why, if that theory were true, we should have to employ a Great Eastern to lay our Atlantic Cables."—Yours, &c., W. E. AYRTON.

April 18th, 1879.

THE ENERGY STORED UP IN AN ELECTROSTATIC CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am really very sorry to have given my courteous antagonist Mr. FitzGerald so much trouble, and he must pardon me if I decline to follow him through a mass of arithmetic and changing units, and into such fearful things as *microjoulads*, because I really do not know what they are.

The difference between us is much simpler. Mr. FitzGerald said (virtually) that the potential of a point or surface was measured by the work that must be done to charge a conductor with unit quantity of electricity up to the same potential, and I said (virtually) that it wasn't.

The only "question of fact" which we differ about is whether the potential of a point *is* so defined or not. Well, it might be perhaps under some inconceivable circumstances, but as a matter of fact it is *not*. Of course I saw what Mr. FitzGerald was driving at, and of course I do not deny for an instant the well-known fact that the energy stored up in a charge Q at the potential V is $\frac{1}{2}$ Q V; but to use this fact in order to define the potential of a point or surface would be, to say the least, very roundabout.

The potential of something is measured by the energy of something else at the same potential; the weight of a thing is measured by the force required to raise another thing of the same weight; the height of a house is measured by the energy stored up in unit quantity of matter when raised to the top of a cliff of the same height; these would be comic definitions. Till the terms are defined, how are we to know when the two things have the same potential, weight, height, &c. But this is not all. The real and original error of Mr. FitzGerald is summed up in the concluding sentence of his last letter, which is followed by a triumphant Q.E.D. The sentence in italics preceding this—viz., that "the potential of a charge is equal to twice the potential energy stored up in unit quantity when accumulated under the same potential" is, though a roundabout statement, a *true* one; but the next sentence, that "the potential of a point or surface is simply that of the static charge accumulated at the point or surface in question" is wholly and utterly false. A point or a surface may have any potential you please without there being the least particle of charge at either.

A charge of positive electricity given to a conductor raises the potential of all points in its neighbourhood, but the charge itself exists only at the surface of separation between the dielectric and the conductor.

I hope I have made my meaning clear, but at any rate I must beg Mr. FitzGerald not to give himself so much trouble over all the other Articles of Faith, in case he sees fit to continue the controversy; because he will find that I shall be usually quite ready to admit all his experimental facts and his arithmetic—his practical experience is too great to allow him to go far wrong in such things as these; it is only when he comes to criticise modern electrical theory that he is, if I may venture to say so, at sea.—Yours, &c., OLIVER J. LODGE.

THE CAPACITY OF A SPHERE IN SPACE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The heresy of Mr. FitzGerald, that a body in infinite space has no capacity, is, I believe, shared by a good many persons, who found their belief on the best of all possible grounds, viz, a hearty acceptance of the fundamental principles connected with the theory of Faraday and Clerk Maxwell concerning electrical induction. The facts on which they base their opinion are true; the conclusion is not true (or, not to beg the question, we will say is not *orthodox*), therefore there must be a flaw in the reasoning; and the flaw is, I think, their misconception of the nature of "infinity." They would say, "It is impossible to give a system of bodies an absolute charge of either positive or negative electricity; in other words, wherever there is a positive charge there must be an equal negative charge somewhere else, connected with it by lines of force." True! Again they would say, "The really active agent in electrostatic phenomena is the polarised dielectric in which the state of strain exists; and the conductors, one at each end, are simply breaks in the continuity of this dielectric, enabling the phenomena called 'charge' to appear at the bounding surfaces." True—most true! Does it, then, follow that a body at an infinite distance from other bodies cannot have a "charge?" By no means.

"But there must be an equal opposite charge somewhere." Well, so there is, at infinity. There need not be any finite charge on any *finite* area; the whole disposable area is infinite, and 0 times ∞ may be anything you like.

The fact is that *any* finite charge can be given to a body in space, but the effect of this charge will be weaker and weaker at greater and greater distances from it until at an infinite distance there will be no effect at all; and whether you then choose to say that there is an equal opposite charge spread all over infinity, or whether you choose to say that there is nothing at all there, makes no difference to anybody.

The most convincing proof of the statement that the capacity of a sphere in space is equal to its radius is, I think, this:—

The capacity of a sphere surrounded by another concentric sphere, to which the other pole of the battery is attached, can be proved to be equal to the product divided by the difference of their radii. Now let the larger sphere increase gradually in size: the capacity of the inner one will decrease gradually, until, ultimately, when the large one is becoming infinitely great, the capacity of the inner one is approaching a fixed limit—its radius. For the expression $\frac{r\,r'}{r'-r}$ becomes equal to r when r' is equal to infinity.

Notice that all the time the enlargement of the outer sphere is going on the density of its charge is continually diminishing (though the quantity remains always the same, and numerically equal to the charge in the inner sphere), until ultimately the density actually vanishes (*i.e.*, approaches the fixed limit, zero). I must apologise for making so much of so elementary a doctrine, but I appreciate so highly the reasons which make people fancy that a body in an infinite dielectric has no capacity, that I wished to point out to them as clearly as I could that the conclusion does not follow from their premises.—Yours, &c.,

OLIVER J. LODGE.

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THE CONSTANTS OF ELECTRIC CURRENT.

BY J. T. SPRAGUE, M.S.T.E.

While the divergence between natural truths and the mathematical expression of their results is attracting attention, it may be well to examine into some effects of this divergence in matters of more consequence than electrostatic potential, or the substitution of this term for the older idea of tension. It is pretty nearly universally believed that the laws of electrical current differ fundamentally from those of material currents, such as the flow of water in pipes. I propose to show that the laws are identical, and that the accepted ideas on the subject are due to the substitution of mere mathematical formulæ for physical facts.

The special character of the accepted laws of electric transmission is that current is in the simple ratio of the forces and resistances, so that doubling the acting force doubles the current, while doubling the resistance halves the current. As a direct consequence, we have the monstrous doctrine that *electrical resistance is equal for all currents*; that is to say, that a given conductor offers equal facility of transmission to all currents. One ohm resistance is one ohm whether a current of one veber or one hundred vebers is passing.

In material currents no such simple ratio between force and resistance exists, and, generally, resistance to motion increases as the square of the current.

As Mr. Siemens, following the universally accepted doctrines, says:—"Electricity is not conducted upon the conditions appertaining to a pipe conveying a ponderable fluid, the resistance of which increases with the square of the velocity of flow."

The force which causes electric motion is termed electromotive force, potential, difference of potentials, difference of tensions, &c., according to the taste of writers, and also according to the conditions of a given case; but we all know that this force is simply an expression—no such actual force exists in nature, and it is developed, in fact, by many different processes; but it is a necessary idea, and embodies in one expression all those actions which generate what we call electrical motion. It is, however, not comparable directly with natural or mechanical forces, because none of these act in the direct ratio of their intensity. But how comes it that E (electromotive force) does so act? *Simply because it is itself merely an expression for the square root of the energy which calls it into existence.* Why do all our units—the volt, ohm, and veber—act in Ohm's formulæ, and vary in their direct ratios? *Because they are themselves the expressions of velocity, and energy varies as the square of the velocity.* The absolute system (and these units are multiples of the absolute unit) is a system of measurement of energy, based upon the velocity imparted by unit force in unit time: consequently they are not concrete matters (which cannot be multiplied together), but completely inter-related. That E, the electromotive force, is simply an expression of the square root of the energy expended is demonstrable mathematically, but I prefer to make it obvious physically. In a given resistance (electrical) R, current C is proportional to electromotive force E, as a well-known fact, continually worked out in Ohm's formula, $C = \frac{E}{R}$. But it is a well-known fact also that the energy of C, whether reckoned as heat or work in any form, varies as the square of C. Hence, as energy in the form of work can only be obtained from any apparatus in the ratio of energy supplied, it follows that E must needs represent energy equal to that of C, and that, therefore, this energy must be expended in E in the ratio of its square. If $C = E$ and the energy of $C = C^2$, then the energy of E also $= E^2$. This is obvious experimentally with batteries, as I have shown it worked out in regular debtor and creditor accounts, pages 235 to 240 of my *Electricity*. If we arrange a cell to give a veber current in one ohm external resistance, plus a resistance equal to that of the cell, we can add a second cell in the place of this resistance, and so double the current without any change in the resistance. We know by experiment that there is now fourfold work doing, as is made manifest in the form of heat in the ohm wire, though E is only doubled. But what is happening in the battery? Four times the weight of zinc is dissolved; each weight of zinc sets free, in the chemical reaction, a definite quantity of energy, so that doubling E (the cells) means expenditure of zinc and supply of energy to the circuit in the ratio of the square of E, and so it is by whatever mode that state of things which we symbolise by E is set up.

Well, mechanical force can be expressed in exactly the same way, though I am not aware that this plan has ever been employed. Mechanical force is, however, often enough expressed as "head of water," and the velocity of flow varies as the square root of the head of water. Current, be it water or be it electricity, is, of course, simply velocity, rendered quantitative by means of a unit of quantity suited to each case. If, then, we represent the "square root of the head of water" by the symbol M, we have what I will call *mechanico-motive force*, strictly analogous to electromotive force, and current or velocity of flow of water varies directly as M, just as current or velocity of unit electricity varies directly as E. But head of water means energy in foot-pounds; it is directly the work done by gravitation, as the head in feet and the weight in pounds, so that our M or *mechanico-motive* force is just a symbol representing the square root of the energy supplied by the force, just as E represents the square root of the energy supplied by the dissolving zinc or other source of electric action. The advantage of both terms and both symbols is that by the condensation of energy expended into its square root it is directly correllated to its work done by means of the velocity set up, and this itself represents the square root of the work done or stored up in the acquired velocity.

But it is necessary to give unit M a fixed value, and we may take the action of gravity for one second as that unit. We may do this in several ways; but, in order to bring the required analogy to the electrical laws as close as possible, we may take, as the basis, the velocity set up—32 feet per second (ignoring for convenience of figures the fractional part of 32·2). But, to obtain a quantitative value for a force or a velocity, we must have either the mass acted upon or the area through which the force or the velocity acts; either will serve, and, of necessity, whichever is chosen defines the value of the other. One square inch of water, two feet in length, is nearly one pound weight, so that if we take a conductor of one square inch section, through which the force acts, we have:—

Unit M = mechanico-motive force = velocity 32 feet per second.
Unit A = conducting capacity = sectional area 1 square inch.
Unit C = current = 16lbs. water per second.

These are the actual conditions due to a head of water of 16 feet, independent of all effects of friction, influence of orifices, &c. $M \times A = C$ will express the flow of water under any varying relations of M and A. But the arithmetical result is the same, whether we multiply by any factor, or divide by the reciprocal of that factor. We may, therefore, take the reciprocal of A, call this R, and change the formula into $\frac{M}{R} = C$. We may also be unwise enough to call this new value the resistance against which the force acts, and then we have not only the actual conditions of the accepted electrical formula, but also the same theory.

Now, what is so called electric resistance but just this mathematical figure, the *reciprocal of conducting capacity?* What is an ohm but a defined *conductor?* It is not a resistance, for its effects compare in no manner of way with any known natural resistance to the action of force. It does exactly accord with the conducting capacity of a pipe, regarded simply a sectional area. But the pipe conveying water has not only a conducting capacity dependent on its sectional area; it has also a resistance, variable in its nature, because compound, but definite for any particular quality of pipe. This resistance is composed of various frictions, of the particles of water among themselves, of the surface of the pipe, of the influence of bends, &c.; but all of these are expressible in a unit term, the head of water needed to overcome them, and in actual pipes the conducting capacity is really a complex result of these frictions and of the area of the pipes. This resistance, however, increases as the square of the current, so that the flow of water varies as M—that is as the square root of the head of water, or energy imparted by gravity, and inversely as R the reciprocal of the conducting capacity, expending energy in the conductor in the ratio of the square of the current.

In what manner does electrical current differ? It, too, varies as E, that is as the square root of the energy derived from the source, and inversely as R, the reciprocal of the conducting capacity (called resistance in ohms) expending energy in the conductor in the ratio of the square of the current.

It is true that there is a physical difference in the modes of transmission of matter in the one case, and of energy in the other, yet as in each case, it is, after all, energy which is absorbed in the resistance by surface friction or molar motion in the one case, and by molecular actions in the other, the total effect is expressible in the same terms, and holds the same relation to the current. In both cases the conducting capacity is affected primarily by the sectional area, varying directly with this, and inversely as the length. This conducting capacity is then lowered in the case of water by the various frictions, in ratios dependent partly upon size, but largely upon the specific quality of the conductor, *i.e.*, upon the nature of its surface. In the case of electricity it depends primarily upon the sectional area because the quality of the resistance to motion is alike throughout the whole body of the conductor, so that the capacity varies directly as the sectional area and inversely as the length, and is lowered or controlled by the specific quality of the conductor, *i.e.*, upon the nature of the material which occupies the sectional area. But these small variations in the conditions of the two currents, once

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they are included in the general expression of the energy expended per unit conductor, no longer affect the results. By tracing out the physical conditions and actions, we find that the accepted laws are not natural truths, but mere arithmetical formulæ; that the supposed difference in the transmission of currents of ponderable fluids and of electricity has no existence, but that both, when the actions are expressed in analogous terms, obey precisely the same laws.

Now, the value of mathematical formulæ cannot be denied; as tools of thought, servants of the intellect, they are invaluable. But they must be kept in their place, they are not theories, they need not, they very commonly do not, correspond to any actually existing facts. Yet there is an inevitable tendency to make them stand for real truths, and to set them up as barriers between us and nature. It is quite time for natural philosophers to resist this tendency, and to insist upon having a clear understanding as to what physical facts and processes are implied by any formula or expression: where they have no such basis, we should recognise that they fill only a similar place in science to that occupied by the pens and ink, slates and pencils, by whose aid we work out the necessary investigations into physical truths.

MOMENTARY CURRENTS IN WIRES.

BY F. C. WEBB, M.I.C.E.

As the question of the various effects of currents in wires, in producing others in the same or neighbouring wires, is occupying the attention of telegraph engineers, it may be useful to attempt a kind of general view of the case as seen by one individual, in order that others may add their views when there is an omission or correct any view when wrong.

We have lately had discussions on this subject, and it seems clear that the relative effects of electrostatic induction, and of what has been termed electro-magnetic induction, are much disputed, and, indeed, it seems that the conditions must be often such as to give one or other the preponderance, whilst in other cases they may be very difficult to unravel from one another.

Let us first consider the case of electrostatic induction. First take the case of a wire, A B, having considerable electrostatic capacity, the outer armature being connected to earth; as, for instance, a gutta percha covered wire in water extended straight, and having the end B connected to earth through a galvanometer. If a battery be applied at A, having its other pole to E, a violent current into the wire will be produced to satisfy the charging of the wire.

We need not enter into the question of the resistance of the galvanometer, &c., but suppose galvanometers placed at A and B without resistance. Then, at first contact, galvanometer A will be violently deflected by the rush in to charge the wire, and B will, after a certain fraction of time, begin to be deflected as the charge is completed, and increase its deflection, whilst A will decrease until both attain equal deflections, as in Fig. 2. On putting A to earth through galvanometer, the needle at A will be violently reversed, as in Fig. 3, by the thick end of the charge rushing out to earth, and B will lessen its deflection, both continuing to lessen their deflection until both deflections cease at the same time.

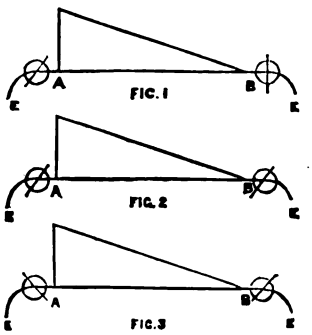

FIG. 1

FIG. 2

FIG. 3

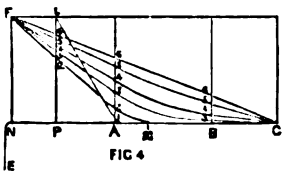

FIG 4

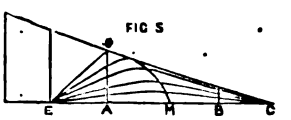

FIG 5

The action of charging is graphically shown in Fig. 4, where N F is the electromotive force of the battery, N P its resistance, P A resistance of galvanometer, A B resistance of wire, B C resistance of galvanometer at distant end. Then, at first instant of contact at P, the potential at P will be P 1 and at A *nil*; the current will be the effect of the whole electromotive force of the battery through the galvanometer only, and will be very great. But the electricity abstracted thus from the pole of the battery will cause the potential then to fall to P 2, and as the wire becomes charged the potential will rise at A to A 2, and as the wire becomes charged, the potential A and P will both rise to 3, 4, 5, until, when the wire is fully charged, the potential at P will P 6 and A, A 6. The curves whose ordinates show the potential at each point in the wire at successive intervals of time will be concave upwards, as shown, but becoming flatter and flatter, until they become the straight line 6 *c* when the charge is complete. This is evident, because at any point *x*, for accumulation to take place, a point any indefinitely small distance nearer to the source must have a greater difference of potential between it and the point *x* than that between *x* and a point an indefinitely small distance further from the source than *x*, so that a greater current may be coming to *x* than is flowing from it during charging, and equal currents flowing to and from *x* and every other point when the charge is complete. The *steepness* of the lines at any point represents the strength of the current at that point. Thus we see the current in the galvanometer at A is very great at first, then suddenly falls, and then gradually falls, whilst that at B begins very feebly and increases until both are equal.

The discharge is shown by Fig. 5. The current in galvanometer at A is produced at first by the full difference between the potential at A, viz., A 6, and that of E, or *nil*. It cannot be so great as that caused when charging, and it gradually decreases. The curves showing the potential in the wire must be concave downwards, and the point of maximum potential will travel in a curve from 6 to M, the centre of the wire.

(TO BE CONTINUED.)

ELECTRICITY AS A SOURCE OF LIGHT.*

BY PROFESSOR REDWOOD.

(CONTINUED FROM PAGE 204.)

In one respect no advancement has taken place since the early days of electric lighting, and in this direction there is still no prospect of advancement. The light is now, as it always has been, produced by the incandescence of carbon. Wood charcoal was first used; but common wood charcoal wears away too quickly; it was, therefore, replaced by hard close-grained box-wood charcoal, which gives an excellent light; but even this is soon dissipated, and it has been found that the hard carbon deposited in gas retorts is much more lasting, although it does not give an equally white and good light. Gas carbon is still used, but not generally now in the state in which it is obtained from the gas works. In that state it contains a good deal of mineral matter which injures the quality of the light, and, therefore, processes have been adopted for preparing it for use.

The best carbons are principally made in France, where there are two makers, Carré and Gaudoin, whose carbons are largely used.

Carré is said to use coke or gas carbon ground to a fine powder and mixed with lamp-black, sugar, and gum. These are made into a paste with water, compressed into the form of sticks, exposed to a red heat, afterwards soaked in a solution of sugar, and heated to redness again.

Gaudoin's process is said to consist in first getting a pure carbon from tar, resin, and other similar substances, and making this into sticks by compression.

Similar manufactures have recently been started in this country.

Now, carbon, in either of the states referred to, possesses three important properties which adapt it for the purpose of producing the electric light. It is a conductor of electricity; its particles are held together by a comparatively weak cohesive force, and these particles, when intensely heated, emit a white light.

But although a conductor of electricity, carbon is not a good conductor, its conducting power being about a hundred times less than that of copper; it therefore offers resistance to the free passage of the current of electricity.

When, under the combined influence of intense heat and the electric current, the cohesive force of the particles is overcome, they fly apart, and pass with the current from one pole to the other. The highly incandescent particles, both those of the solid carbon points and those which have been volatilised and are passing over in the flame, become so many centres from which light is radiated.

The volatilised particles of carbon are the conductors of the electric current, without which the current would not pass, on account of the lowness of its tension.

The rarefaction of the surrounding air, or possibly merely the heat of the flame itself, when the poles (in a horizontal position) are separated from each other to a distance of half an inch or so, causes the intervening light to assume the form of an arch. This, which is called the electric arc, was first produced by Sir Hum-

* Substance of a lecture delivered before the Pharmaceutical Society of Great Britain, Wednesday, January 8, 1879.—(From the Journal of the Society.)

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phrey Davy in 1813. The two solid carbon terminals were called electrodes by Faraday, this term signifying the way by which the electricity passes in or out. They are now more commonly called poles. The one at which the electricity passes out is called the positive pole, and is distinguished by the mark or symbol +, and the other is called the negative pole, and is distinguished by the symbol —.

While the light is being produced, particles of carbon are constantly passing from the positive to the negative pole; the one is therefore wasting, and the other growing. This at least would be the case if there were no oxygen present, as, for instance, if the carbons were enclosed, as they might be, in a glass globe from which the air was removed, or if some gas free from oxygen were contained in it. But if the carbons are surrounded with atmospheric air of oxygen, they will both be consumed in the usual way, by combustion. The positive pole, however, will waste more quickly than the negative, partly because some of its particles will have gone over to the negative pole, and partly because the positive is always hotter than the negative pole. The electric current cannot pass from one pole to the other, when they are separated, without having a continuous line of volatilised particles of carbon to conduct the force, and there must be a discharge of the electricity to produce the heat by which this volatilisation is effected. The electricity we use, being in a low state of tension, cannot spring from one pole to another through non-conducting air. It is therefore necessary to bring the poles together at starting, so as to heat the few particles that thus are brought into contact to the temperature required for their volatilisation, and then we can separate them to a certain extent to produce the light. The distance to which they can be separated will depend upon the tension of the electric force, and if from any cause the current should be broken, the poles must be brought together again to re-establish it.

Now one of the difficulties originally experienced was that of always keeping the poles at the proper distance from each other, and it has been to meet this difficulty that the various forms of lamp I have to bring under your notice have been invented.

The apparatus I have been using was introduced many years ago by Warren De la Rue, and is a very convenient one for the lecture table, but it does not possess any self-adjusting power, the position of the carbons being regulated by the hand of the operator.

In 1846, '47, and '48, patents were taken out by Mr. Staite, in which he describes several forms of apparatus to be used for regulating the position of the carbons. Two of his regulators are figured in drawings I have here, which are, in fact, the same that I used thirty years ago. It will be observed that one of these, in which the carbons are placed vertically one over the other, is essentially the same in principle as the Duboscq lamp which we are accustomed to use at our lectures, and also the Serrin, which, I believe, was the first publicly used for the production of the electric light in London, being that, or a modification of it, with which the lights are produced at the Gaiety Theatre.

In lamps of this construction the position of the carbons is regulated partly by clockwork and partly by the force of magnetism developed by the electric current. Several different forms have been adopted by different makers, some more simple than others, but they all consist of somewhat complicated mechanism.

Attempts have been made, originally in Mr. Staite's time, and again more recently, to simplify the apparatus. Here we have one of Mr. Staite's earliest productions, patented by him in 1846, which was a near approach to the Jablochkoff's candle. It consists of two carbon rods, partly enclosed in brass tubes, while the exposed points rest on a plaster of paris cylinder, against which they are pressed by springs contained within the brass tubes. The two points are thus kept constantly in the same relative positions notwithstanding the wasting caused by volatilisation and combustion of the carbons.

The more complex, and, I believe, more successful apparatus of Rapieff, which is used for lighting the compositors' rooms in the printing establishment of *The Times* newspaper, is a double arrangement of a somewhat similar description, in which there are two positive and two negative poles placed vertically, and kept in position by a weight and a magnet. One of the advantages claimed for this apparatus is that the carbons can be easily replaced, one at a time, without extinguishing the light.

Now these are all modifications of forms of apparatus that were among the earliest of those introduced thirty years ago. It must be recollected that at that time the electricity used was that of the battery, and the current, therefore, was all in one direction. It was no easy matter to get the required supply of electricity from that source, and practically it was impossible to maintain a uniform supply for any length of time. The fuming acid pots became exhausted. The force of the current slackened, and unless the position of the carbons was quickly readjusted, the light became extinguished, and the process of re-lighting had to be gone through. In fact, each light required an attendant to keep it in order.

Under such circumstances, after the lapse of a few years, during which the zeal of inventors wore itself out, by common consent the electric light was relegated to the use of lighthouses, where magneto-electric machines were brought into use for supplying the electricity.

A new era had now commenced in the history of electric lighting. In 1858 the system was first introduced at the South Foreland Lighthouse, and subsequently at Dungeness, Cape Grisnez, and elsewhere. In those cases the electric current was produced by means of large, ponderous magneto-electric machines, which, although required for supplying only a single light each, were giants in comparison with the dwarfish, insignificant-looking machines now employed for supplying all the lights at the Thames Embankment or Holborn Viaduct.

The merit of introducing this system in lighthouses is due to Mr. Frederick H. Holmes, who may be said to have thus laid the foundation of all that has been effectively done in the way of applying the electric light to any great and useful purpose.

It is a remarkable fact that the apparatus first employed by Mr. Holmes for the electric light had been constructed for a very different purpose—namely, that of producing gas from water, for which a company was formed in Paris in 1853. In connection with that undertaking, large magneto-electric machines were employed for decomposing the water and producing hydrogen gas. But the company came to nothing, and Mr. Holmes, who was employed in winding up the concern, conceived the idea of turning the machines to account for the production of light in another way, and applying it in lighthouses. The idea was at first ridiculed, for although magneto-electric machines were then frequently used for experimental purposes, no one had thought of making them available for the production of currents of electricity far greater, more constant and uniform than any previously produced. Mr. Holmes, however, demonstrated the feasibility of effecting his object, and having reconstructed and improved the machines, produced with them a light which, for lighthouse purposes, is certainly unequalled.

(TO BE CONTINUED.)

TELEGRAPH SHARE LIST.

Companies.	Closing Prices April 23.		Business Done Week Ending April 23. Highest.	Lowest.
Anglo-American ....ex div.	54½,	5	54½	53½
Do. "B" ....ex div.	83½,	4	83½	82½
Do. "A"	25¾,	7½	27½	24½
Brazilian	6⅞,	⅜	6⅞	6⅞
Cuba	8,	¼	—	—
Do. Ten per Cent. Preference	15½,	16½	16	16
Direct Spanish	1½,	2	—	—
Do. Ten per Cent. Preference.ex div.	10,	¼	10⅛	10⅛
Direct United States	10⅞,	11	10¾	10¾
Eastern ....ex div.	7 7-16,	9-16	7⅞	7 7-16
Do. Six per Cent. Debenture.ex div.	103,	6	—	—
Do. Five per Cent. do.	100,	3	—	—
Do. Six per Cent. Preference..x div.	11¼,	¼	11¼	11¼
Eastern Extension ....ex div.	7⅞,	⅛	7 9-16	7 7-16
Do. Six per Cent. Debenture	105,	9	—	—
German Union	7⅞,	8⅛	—	—
Globe Telegraph and Trust ....ex div.	4 13-16,	15-16	4⅞	4⅞
Do. Six per Cent. Preference.x div.	10 13-16,	15-16	10⅞	10⅞
Great Northern....ex div.	7⅞,	8⅛	8⅛	7 15-16
Indo-European ....ex div.	20,	1	20⅛	20⅛
Mediterranean Extension ....ex div.	2⅞,	3⅛	3 1-16	3 1-16
Do. Eight per Cent. Preference.x d.	9⅛,	⅞	—	—
Reuter's	9½,	10½	—	—
Submarine	220,	30	221½	221
West India and Panama	1⅝,	¼	1⅛	1⅛
Do. Six per Cent. Preference	8⅞,	⅛	8⅞	8⅞
Western and Brazilian	3⅛,	4	4	4
West. Union Seven per Cent. 1st Mort.	114,	18	—	—
Do. Six per Cent. Sterling	102,	4	—	—

TRAFFIC RECEIPTS FOR MARCH, 1879.

Companies.	March 1879.	March 1878.	Increse.	Decrse
Anglo-American Telegraph Company	47,550 estd.	—	—	—
Brazilian Submarine Company	13,052	14,239	—	1,187
Cuba Submarine Company	3,100 estd.	3,517	—	417
Direct Spanish Telegraph Company	929	880	49	—
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	26,185	23,112	3,073	—
Eastern Telegraph Company	41,225	38,201	3,024	—
Great Northern Telegraph Company	15,401	—	—	—
Submarine Telegraph Company	9,790	10,055	—	265
West Coast of America Telegraph Company.	—	—	—	—
Western and Brazilian Telegraph Company..	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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NOTES.

South African Telegraph Cable.—The Rangoon, with the first portion of this cable on board, has passed through the Suez Canal; the second ship is expected to sail about the middle of May.

The United States Cable Company (Limited).—The directors have resolved upon the payment of an interim dividend of 5s. per share, being at the rate of 5 per cent. per annum, for the quarter ending 31st March last, such dividend to be payable on and after the 16th May next.

A New Cable between Germany and Norway.—In order to promote the carrying out of an arrangement concluded between the Telegraphic Administrations of Germany and Norway, a company was constituted on April 23 in the office of the United German Telegraph Company for the laying and maintenance of a cable between Germany and Norway.

Science for All.—In the current number of this periodical is an article on "The Mariners' Compass." As a rule the information given on the various subjects treated is fairly good, but we cannot say as much for this article. The author seems to have worked up a few points in the history of the compass, but even this part is incomplete; and the modern improvements and investigations are seemingly unknown.

Austria-Hungary.—The full data from which to estimate the telegraphic position of Austria to the end of 1877 has only recently been published. During the year the receipts increased by 82,108fl., but it is necessary to state that this increase can hardly be regarded as a flourishing sign, inasmuch as it includes the receipts from the new lines, which have averaged about 100 miles per year for some years. The number of government telegrams was 64,695, against 71,930 in the previous year; private telegrams numbered 4,032,838, against 3,747,580, being a decrease of 7,235 in the former case and an increase of 285,258 in the latter. Through messages were as follows:—Government 8,707, against 8,523, or an increase of 184; private 634,451, against 584,688, or an increase of 49,763.

The House of Commons and the Telephone.—Edison's loud-speaking telephone was exhibited on Tuesday, April 29, at the rooms of the Royal Society, Burlington House, to Mr. Spottiswoode, President of the Royal Society, and the following gentlemen, many of them being members of the Committee on Reporting:—The Speaker of the House of Commons, the First Lord of the Admiralty, Mr. W. E. Forster, Sir John Lubbock, Sir Henry Holland, Mr. Mitchell Henry, Mr. Walter, Dr. Lyon Playfair, Mr. A. Mills, Mr. Barclay, Mr. Lewis Fry, and Sir Thomas Erskine May. By the kindness of Professor Tyndall one end of the wire was placed in the laboratory of the Royal Institution, and a passage from Mr. Gladstone's speech of Monday night, read by a gentleman in Albemarle-street, was clearly heard by the gentlemen at Burlington House.

The American Cable Company.—The proposed Transatlantic line of this Company is stated to include—first, a cable from New York to the island of Flores, one of the Azores. The copper conductor of this cable is to weigh five hundred pounds per knot. Secondly, a cable from Flores to France, England and Holland. Thirdly, a cable from Flores to Fayal, San Miguel and Lisbon. It is stated that a cable will also be laid from Lisbon to Genoa. Altogether, it is proposed to lay 7,300 miles of cable, including 4,200 miles of main deep-sea line. A through signalling speed of 25 words per minute is anticipated, by the use of the mirror instrument. About 2,000 miles of cable, including the lines between Brest, Belgium and Holland; between Brest and England; and between Lisbon and Italy, are to be heavily armoured; and there would be about one hundred miles of heavy shore-end, weighing eighteen and a half tons per mile. The steamer for laying the cables is estimated to cost from £60,000 to £75,000.

The Breaking-in of Horses by Means of Electricity.—According to *La Nature*, the General Omnibus Company of Paris has for some time past made use of electricity for breaking-in the horses destined for the service of its vehicles. At a recent sitting of the *Société Nationale d'Agriculture*, M. Bella gave some interesting details in relation to this subject, from which it appears that vicious horses, addicted to biting, kicking, &c., speedily submit and become inoffensive, so that they may be harnessed and groomed with safety, after undergoing the electrical discipline. To obtain this result a weak electric current was passed through the animal's mouth whenever it showed restiveness. The current was generated by a small Clarke magneto-electric machine, one of the wires from which communicated with the bit (one pole being, no doubt, put "to earth.") This idea has been suggested at the Paris Exhibition, where, in the Swedish section, was exhibited a small box containing a battery communicating with a bit by means of the reins. When the horse to which this apparatus was adapted showed any symptom of viciousness, the conductor was simply to press a small button, when the animal would immediately become subdued. The use of electricity is said to be much less liable to the charge of cruelty than are the means ordinarily adopted for the breaking-in of horses.

A Disclaimer from America.—As soon as the American papers heard of "Cowper's Electric Writing Instrument" they hastened to claim the invention for America. Unfortunately for these writers, honour is not altogether lost in the breasts of the scientific men of America, and mere newspaper statements have received a rude shock by the following letter addressed to our American contemporary, the *Journal of the Telegraph*:—"Hamilton, Ohio, April 5: I notice in the last number of the *Journal of the Telegraph* a description of Cowper's Writing Telegraph system, and editorial remarks on the efforts to claim credit. I am never a claimant for things I *intended* to do, and do not wish to be classed as such. I, with many others, may have given thought to subjects tending toward a certain end, but when some one else presents thoughts in a material shape, he and he only is entitled to credit. We have *talked* of what we would do, what we could do, and what we wanted to do. What good does that do the world? Mr. Cowper presents the world with something *done*, not *talked* about. It should be understood by those who flood the world with evanescent thought from massive minds, that he who first presents a tangible and useful something is the proper person to receive any applause the subject may merit. The device presented by me to the Electrical Society of the Ohio Valley is interesting and plausible, and worth study, and the idea of

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presenting the thing to the Society was suggested by the announcement of Mr. Cowper's *work*.—J. W. See."

Electrolytic Conduction.—Professor Tate, speaking of this subject at one of the meetings of the Royal Society of Edinburgh last session said, "It is commonly said that there is a resistance to a current at the surface of contact of a solid conductor and an electrolyte. Some good authorities, however, say that we have, as yet, no proof of this, as the effects observed may be due to polarisation. It is obvious that if the reverse electromotive force due to polarisation contain a term directly proportional to the strength of the current, the ordinary methods of measurement would not enable us to distinguish this from the surface resistance above mentioned. For, in the expression $I = \frac{\Sigma (E)}{\Sigma (R)}$, if the numerator contain a term of the form $-e\,I$, it may be expunged, provided e be added to the denominator. To clear up this point, I have recently made a number of experiments. These have led me to some curious results bearing on the theory of electrolysis, which I propose to bring before the Society on a future occasion. At present I refer to them merely so far as to say that they establish fully the existence of the surface resistance above mentioned. Thus I was led to see that if a slip of platinum be inserted between the electrodes of a decomposing cell it ought, except in extreme cases, to produce almost precisely the same result as a similar and equal slip of glass or mica. This was easily verified. Here we have the singular result of a marked diminution of the current by the insertion into the electrolyte of a substance which is in itself a much superior conductor. Even when the platinum completely closes the path from one electrode to the other, so as to form two decomposing cells instead of one, a comparatively small hole made in it at once changes its function from that of common electrode to each of two decomposing cells into that of a mere *obstruction* in one cell. It is an interesting experimental inquiry to trace the intermediate stages between these states, as a pinhole in the platinum is gradually enlarged. Whatever, then, be the behaviour of the particles of an electrolyte, they do *not* behave like little pieces of platinum."

Cantor Lectures.—Mr. W. H. Preece, of the Postal Telegraph Department, gave on Monday evening, at the Society of Arts, the second of the Cantor lectures on recent improvements in telegraphy. The earliest lines constructed in this country, and their insulation by means of pitch and of goose quills were first referred to by the lecturer, who in the course of his lecture mentioned that the Post Office has effected improvements in the quality of wire used for telegraphy by the strict application of the laws discovered by experimental science, so that the working power is increased 50 per cent. The new insulator introduced by the office has made it possible to carry on operations during the late bad weather without any trouble or difficulty. A new form of overland wire, consisting of steel coated with electro-deposited copper, was favourably referred to. There are in Great Britain 10,000 miles of underground lines, but the known facts which tell against the extension of underground lines are that there is an increase of three or four times in the cost, and the capacity for carrying currents is reduced three or four times. Birds were said to be the greatest enemies of overland wires; and the interesting fact was mentioned that their insulation is at its worst shortly before sunrise and after sunset. The gutta-percha coating employed for underground wires is found to be attacked not only by rats and mice, but very largely by a minute insect, the springtail or *Tempeltonia Crystallina* (Lubbock), and is also influenced by fungus. Speaking of submarine cables, Mr. Preece pointed out that the chief dangers to them were from ships' anchors, from grounding icebergs, from stone corrosion where mineral veins are present, from submarine landslips, volcanic outbursts, and sinking ships. The General Post Office have, apart from company cables, as much as 3,809 miles of cable. Their total length of land wires is 110,095 miles, which runs on 24,885 miles of line. Many lines in the country have several wires to each line. The totals are made up thus, the numbers being miles:—Roads—line, 11,055; wire, 39,821; railways—line, 12,952; wire, 58,127; canals—line, 432; wire, 4,123; underground—line, 446; wire, 9,024. The lecture was very fully illustrated by specimens, and besides some of historical interest, there was shown a piece of the new cable for the Cape.

A Telephone Twenty-eight Years Ago.—Mr. Brackett, writing to the *Scientific American*, says:—"In the latter part of 1851 Mr. Edward Farrar, of Keene, N.H., was occupying leisure moments in trying to transmit sounds over a telegraph wire, and actually succeeded in telegraphing music, and used a true telephone as a receiver! Some three years after his first actual telephonic success he had a correspondence with the Professors Silliman, of Yale College, with view of pursuing his work farther, but the replies he received were of such nature as to lead him to suppose that further attempt was hopeless, and under that impression and pressure of professional duties he laid it aside. I have before me some of that correspondence, and will quote from one of Mr. Farrar's letters a description of his experiment, and a statement which shows how closely he came to inventing a complete speaking telephone: 'Each reed of a melodeon is furnished with a small metallic point, which, while the reed is at rest, approaches near to the surface of mercury in a very small cup underneath the reed, into which the point dips when set in motion. The reeds are connected with one pole of a battery, and the cups with the other. The current is broken with each vibration of the reed. At the remote end of the wire is a temporary magnet, with an armature fixed upon a spring in near proximity to the magnet, and which is affected as a reed at the other end of the line is set in motion.' What he here calls a 'spring' is seen to be a real telephone. It was made of two upright thin spruce boards, A A, to one of which was fixed the armature B, and to the other the electromagnet C. The boards were seven or eight inches wide, about two feet long, and placed half an inch apart, and joined at the top by a strip glued between them. He continues: 'The effect is that the armature vibrates with the reed set in motion, and, the pitch of a sound depending on the rapidity of vibration, it will be the same in the reed and armature. A tune on the instrument will therefore produce a tune on the armature. What may appear somewhat strange, several different tones may be heard when chords are struck upon the instrument. The object of my inquiry was this. If the current power could be varied by some slight variation of a vibrator to be affected by the atmosphere as the tympanum of the ear is, the supposition is that the sounds of the voice might be reproduced by the means stated above (!).' When it is remembered that Mr. Farrar penned the above in May, 1854, it is be regretted that he was turned aside from so interesting an inquiry at so critical a point, and that he did not take that one step which would have then produced the speaking telephone."

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ON ELECTRIC LIGHTING.—FIRST PAPER.*

BY DR. JOHN HOPKINSON, F.R.S., M. INST. M.E.

During the last year much has been written and much information communicated concerning the production of light from mechanical power by means of an electric current. The major portion of what has appeared has been either descriptive of particular machines for producing the current, and of lamps for manifesting a portion of its energy as light; or a statement of practical results connecting the light obtained with the power applied and the money expended in producing it.

Whilst fully appreciating the present value of such information, the author has felt that it did not tell all that was interesting or practically useful to know. It is desirable to know what the various machines can do with varied and known resistances in the circuit, and with varied speeds of rotation; and what amount of power is absorbed in each case. It is a question of interest, whether a machine intended for one light can or cannot produce two in the same circuit, and if not, why not; whether a machine, such as the Wallace-Farmer, intended as it is for many lights, will give economical results when used for one; and so on. It is clear that the attempt to examine all separate combinations of so many variables would be hopeless, and that the work must be systematised.

The mechanical energy communicated by the steam-engine or other motor is not immediately converted into the energy of heat, but is first converted into the energy of an electric current in a conducting circuit; of this a portion only becomes localised as heat between the carbons of the electric arc; and of this again a part only becomes sensible to the eye as light. The whole of what we need to know may be more easily ascertained and more shortly expressed if the inquiry is divided into two parts: (*a*) what current a machine will produce under various conditions of circuit, and at what expenditure of mechanical power; (*b*) having given the electric conditions under which the arc is placed, no matter how these conditions are produced, what light will be obtained therefrom. Parts of the subject have been treated more or less in this sense by Edlund (Pogg. Annal. 1867 and 1868), Houston and Thomson in America, Mascart ("Journal de Physique,' March 1878), Trowbridge ("Philosophical Magazine," March 1879), Schwendler (Report on Electric Light Experiments), but not so completely that nothing remains to be done; nor does the author doubt that a very great deal of information is in the hands of makers of machines, which they have not thought it desirable to make known. The present communication is limited to an account of some experiments on the production of currents by a Siemens medium-sized machine; that is, the machine which is advertised to produce a light of 6,000 candles by an expenditure of 3½ horse-power.

All the machines for converting mechanical power into an electric current consist ultimately of a conducting wire moving in a magnetic field; and, approximately, the electromotive force of the machine will be proportional to the velocity with which the circuit moves through the field, and to the intensity of the field. In general the intensity of the field is not constant; and in such machines as the Siemens and ordinary Gramme machines it may be regarded as a function of the current passing. We must learn what this function is for the machine in question; or —which comes to exactly the same thing, and is better so long as the facts are merely the result of experiment—we must construct a curve in which the abscissæ represent currents passing, and the ordinates the electromotive force for a given speed of rotation. But the power of a current, that is its energy per second, is the product of the electromotive force and the intensity; this is in all cases less than the power required to drive the machine, and the ratio between the two may fairly be called the efficiency of the machine.

The object of the enquiry may, perhaps, be made clearer by an illustration. Consider the case of a pump forcing water through a pipe against friction; then the electric current corresponds to the water passing per second, and the electromotive force to the difference of pressure on the two sides of the pump; and just as the product of pressure and volume per second is power, so the product of electromotive force and current is power, which is directly comparable with the power expended in driving the machine or the pump, as the case may be. The peculiarity of the so-called dynamo-electric machine lies in this, that what corresponds to the difference of pressure (the electromotive force) depends directly on what corresponds to the volume passed (the current).

Each experiment requires the determination of the speed, the driving power, the resistances in circuit, and the current passing: or of the difference of potential between the two ends of a known resistance of the circuit.

The apparatus employed by the author was arranged, not alone with an aim to accuracy, but in part to make use of such instruments as he happened to possess, or could easily construct, and in part with a view to ready erection and transport. Much more accurate results may be obtained by anyone who will arrange apparatus with a single aim to attain the greatest accuracy possible. The author's apparatus will, however, be briefly described, that others may form their own opinion of the importance of the various sources of error.

The speed counter was that supplied with the machine.

Concerning the steam engine, nothing need be said save that its speed was maintained very constant by means of a governor shown in Fig. 1, and specially arranged for great sensibility. By placing the joint A above the joint B, instead of below it as in Porter's governor, any degree of sensibility up to instability may be obtained. The speed was varied by means of a weight and a spring, attached to a lever on the throttle-valve spindle. The ungainly appearance of this governor could easily be remedied by any one proposing to manufacture it.

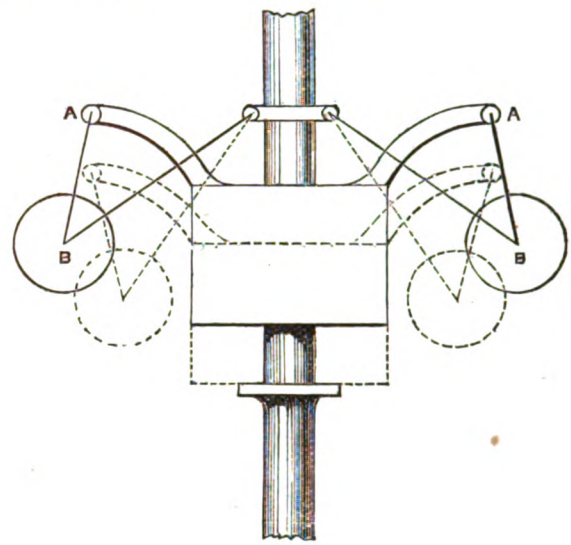

FIG. 1.

The power is transmitted from the engine to a countershaft by means of a strap, and by a second strap from the countershaft to the pulley of the machine. On this second strap is the dynamometer shown in Fig. 2.

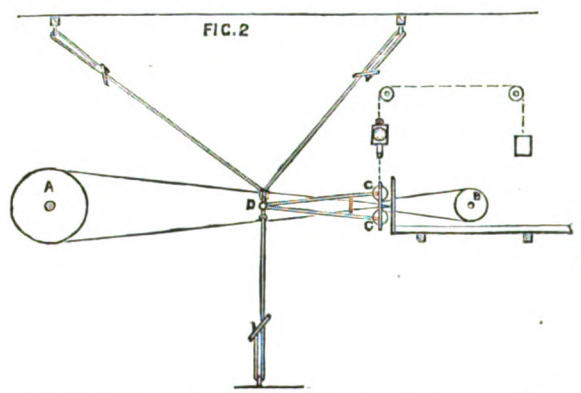

FIG. 2

This dynamometer has for some time been used by Messrs. Siemens, and was also used by Mr. Schwendler; its invention is due to Hefner von Alteneck. A is the driving pulley; B the pulley of the electric machine; CC are a pair of loose pulleys between which the strap passes; these are carried in a double triangular frame, which can turn about a bar D. This bar might form part of a permanent structure; but in order to place the dynamometer readily on any strap, the bar in this case provided with eyes at either end, and secured in position by six or eight ropes. This plan answers well, as there is very little stress on the bar. From the frame immediately above the pulleys a cord leads through a Salter spring balance over snatch-blocks to a back balance-weight; the tension of this cord is read on the spring balance. At first the spring balance was omitted, and the weight at the end of the cord was observed; but the friction of the snatch-block pulleys was found objectionable. The pulley frame carries a pointer, which is adjusted to a fiducial mark when the line AB bisects the distance between the loose pulleys. Let W′ be the tension of the cord required to bring the pulley frame to its standard posi.

* Read at Institution of Mechanical Engineers.

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tion when no work is being transmitted; W″ the tension which is required to bring the pointer back to the fiducial mark, when an observation is made; and let W=W′−W″. Let T′ T″ be the tension in the two parts of the strap; R_1 R_2 r the radii of the pulleys A, B, and C, plus half the thickness of the strap; C_1 C_2 the distances AC, CB; d the distance apart of the centres CC; a_1 a_2 the inclination of the two parts of the strap to the line AB. Then

$$(T' - T'')(\sin. a_1 + \sin. a_2) = W;$$

$$\text{and } \sin. a_1 = \frac{R_1 + r - d}{C_1} + \frac{d}{2C_1}\left(\frac{R_1 + r - d}{C_1}\right)^2,$$

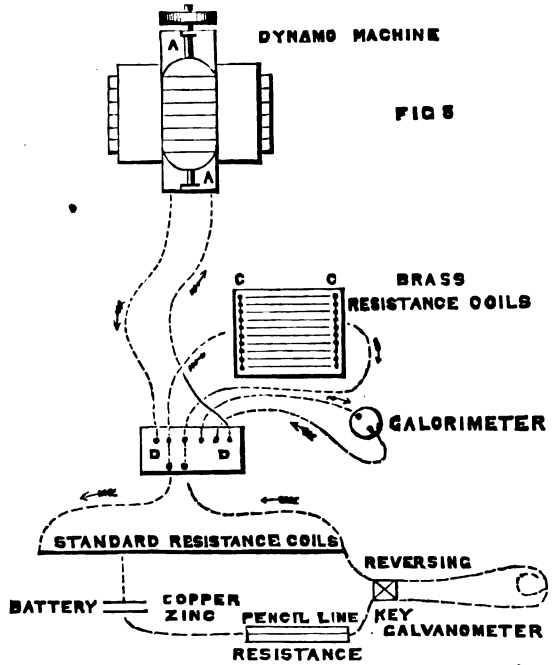
$$\sin. a_2 = \frac{R_2 + r - d}{C_2} + \frac{d}{2C_2}\left(\frac{R_2 + r - d}{C_1}\right)^2,$$

very nearly.

The value of T′−T″ and the velocity of rotation of the machine being known, the power received is readily obtained, expressed in gram-centimetres per second. Multiplying by 981 the value of gravity in centimetres and seconds, the power is then expressed in ergs* per second, and is ready for comparison with the results of the electrical experiments.

As already stated, the dynamo-electric machine in the present case was a Siemens medium size; the armature coil has fifty-six divisions, and the brushes are single, not divided—that is, each brush is in connection with one segment of the commutator at any instant.

The leading wire is 100 yards of Siemens No. 90, consisting of seven copper wires, insulated with tape and india-rubber, and having a diameter of about 9·6 mm.



The method of determining the current is shown in the diagram, Fig. 3. The current is conveyed from the machine A, through a set of coils of brass wire *c*, and in some cases through a resistance coil placed in a calorimeter, and so back to the machine, the connections being made through cups of mercury excavated in a piece of wood, D. The current passing may be ascertained by the heating of the calorimeter, or by measuring the difference of potential at the extremities of the resistance *c*, all the resistances of the circuit being supposed known. This difference of potential could, of course, be very easily measured by means of a quadrant electrometer; but, as the instrument had to be frequently removed, a galvanometer appeared more convenient. The two points to be measured are connected to the ends of a series of resistance coils *a b*. The galvanometer is placed in a second derived current, passing from junction *a b* through a single Daniell element, a set of high resistances for adjusting sensibility, a reversing key, the galvanometer, the reversing key again, and so to the other extremity of *b*. The electromotive force is ascertained by adjusting *b* so that the deflection of the galvanometer is *nil*.

The resistance coils *c* comprise ten coils of common brass wire, each wound round a couple of wooden uprights driven into a baseboard common to the set; each wire is about 60 metres long, and of No. 17 Birmingham wire-gauge, weighing about 14·6 grams per metre. Each terminal is connected to a cup of mercury excavated in the baseboard, so that the coils can be placed in series or in parallel circuit at pleasure. The resistance of each coil being about 3 ohms, this set may be arranged to give resistances varying from 0·3 to 30 ohms.

The calorimeter is a Siemens pyrometer with the top scale removed; a resistance coil of uncovered German silver wire, nearly 2 m. long, 1·5 mm. in diameter, and having a resistance of about $\frac{1}{5}$ ohm, is suspended within it from an ebonite cover, which also carries a little brass stirrer; and the calorimeter is filled with water to a level determined by the mark of a scriber. It was, of course, necessary to know the capacity of the calorimeter for heat. It was filled with warm water up to the mark, and the coil placed in position; 120 grammes of water were then withdrawn, and the temperature of the calorimeter was observed to be 58·8° C.; after the lapse of one minute it was 58·3° C.; after a second minute 57·9° C.; 120 grammes of cold water, temperature 13·3° C., were then suddenly introduced through a hole in the ebonite cover, and it was found that, two minutes after the reading of 57·9°C., the temperature was 50·0° C.; hence we may infer that the capacity of the calorimeter is equal to that of 740 grammes of water. Two similar experiments at lower temperatures gave respectively the numbers 749 and 750. Estimating the capacity from the weight of the copper cylinder supplied with the pyrometer, it should be 747, to which must be added the capacity of the German silver wire and stirrer. Taking everything into consideration, 750 grammes may be assumed as the most probable result.

The resistance coils, marked *a b* in the diagram, Fig. 3, are of German silver, made by Messrs. Elliott Brothers; they are on the binary scale from $\frac{1}{8}$ ohm to 1024 ohms. Separate coils were used, instead of a regular resistance box, because they were more readily applicable to any other purpose for which they might be required; and the binary scale was adopted, because the coils could at once be used as conductivity coils in parallel circuit also on the binary scale. Each coil as supplied terminated in two stout copper legs; these were fitted with cups of india-rubber tubing for mercury, whereby any connections whatever could readily be made. This arrangement, though rude, was very convenient, and perhaps even safer from error than a box with brass plugs to make the connections. By a slight alteration of the connections the whole was instantly available as a Wheatstone's bridge to determine resistances.

The battery was a single element of Daniell's battery, in which the sulphate of zinc solution floats on the sulphate of copper; its electromotive force is assumed to be $\frac{2}{3}$ volt.

The resistances added in the battery circuit are pencil lines on glass, such as are described in the "Philosophical Magazine" of February last. Three were used, giving a range of sensibility approximately in the proportions 1, 25, 170, 700; they are very useful in adjusting the resistance *b* so as to give no deflection of the galvanometer.

The reversing key belongs to Sir W. Thomson's electrometer, and is quite suitable when high resistances and *nil* methods are used.

The galvanometer is far more sensitive than is necessary, and has a resistance of 7,000 ohms.

Preliminary to experiments on the current, determinations of resistances were made. The resistance of each brass coil was first determined, to afford the means of calculating the value of *c* in any subsequent experiment. When the ten are coupled in parallel circuit, the calculated resistance was 0·29 ohm, whilst 0·292 was obtained by direct measurement. The leading wire was then examined; the further ends being disconnected, the insulation resistance was found to be over 60,000 ohms; how much over it was immaterial to learn. When the ends of the cable were connected the resistance was found to be 0·129 ohm. The resistances in the machine were found to be as follows when cold: magnet coils 0·156 and 0·152 respectively, armature coil 0·324; total 0·632. Direct examination was made of the whole machine in eight positions of the commutator, giving 0·643 ohm, with a maximum variation from the mean of 0·6 per cent. After running the machine for some time the resistance was found to be 0·683, an increase which would be accounted for by a rise of temperature of 12° C. or thereabouts. The resistance of the calorimeter is 0·20, without its leading wire, which may be taken as 0·01. We have then in circuit three resistances which must be considered: (1) the resistance of the machine and leading wire, assumed throughout as 0·81, denoted by c_1; (2) the resistance of the brass coils C, calculated from the several determinations, with the addition of the resistance of the leading wire 0·02, and denoted by c_2; (3) when present, the resistance of the calorimeter and leading wire, denoted by c_3.

Two approximate corrections were employed, and should be

*The dyne is the force which will in one second impart to one gram a velocity of one centimetre per second, and an erg is the work done by a dyne working through a centimetre; a horse-power may be taken as three-quarters of an ergten per second, an ergten being 10^{10} ergs. See Report of Brit. Assoc., 1873, and Everett "On the C. G. S. System of Units," published by the Physical Society.

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detailed. The first is the correction for the considerable heating of the resistance coils c. These were arranged in two sets of five each, five being in parallel circuit, and the two sets in series. The current from the machine, being about 7·4 Webers in each wire, was passed for three or four minutes; the circuit was then broken, and the resistance c_2 was determined within one second of breaking circuit, when it was found to be about 5 per cent. greater than when cold. As the resistance was falling, the following was adopted as a rule of correction: square the current in a single wire, and increase the resistance c_2 by $\frac{1}{10}$th per cent. for every unit in the square. The second correction is due to the fact that the calorimeter was losing heat all the time it was being used. It was assumed that it loses 0·01° C. per minute for every 1° C. by which the temperature of the calorimeter exceeds that of the air; this correction is of course based on the experiment already mentioned.

The method of calculation may now be explained:—

R is the total resistance of the circuit, equal to $c_1 + c_2 + c_3$;

Q is the current passing in Webers;

E the electromotive force round the circuit in Volts;

W_1 the work per second converted into heat in the circuit, as determined by the galvanometer, measured in ergtens per second;

W_2 is the work per second as determined by the calorimeter;

W_3 is the work per second as determined by the dynamometer, less the power required to drive the machine when the circuit is open;

HP is the equivalent of W_3 in horse-power;

n is the number of revolutions per minute of the armature.

Then:

$$Q = 981 \times \frac{a+b}{b} \times \frac{1}{c_2},$$

$$E = QR,$$

$$W_1 = EQ;$$

also $W_2 = \frac{R}{0{\cdot}2}$ multiplied by the mechanical equivalent of the heat generated per second in the calorimeter.

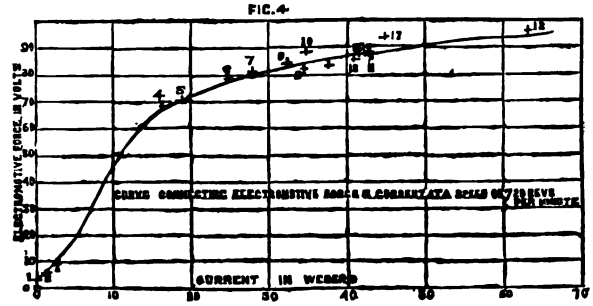
The accompanying table gives the results of the experiments. A power of 0·21 ergtens, or 0·28 horse-power, was required to drive the machine at 72 revolutions on open circuit. An examination of the table shows that the efficiency of the machine is about 90 per cent., exclusive of friction. Comparing experiments 11 and 13, and also the last four experiments, it is seen that the electromotive force is proportional to the speed of rotation within the errors of observation. Experiments 14, 15, and 16 were intended to ascertain the effect of displacing the commutator brushes.

TABLE I.

No. of Experiment.	R	Q	E	W_1	W_2	W_3	H.P.	n	Position of Commutator Brush.
1.	1025	0·0027	2·72	.....	.....	.....	.....	720	Original position, as supplied from maker.
2.	8·3	0·48	3·95	0·0019	.....	.....	.....	,,	,,
3.	5·33	1·45	7·73	0·0112	.....	0·042	0·056	,,	,,
4.	4·07	16·8	68·4	1·149	1·140	1·179	1·59	,,	,,
5.	3·88	18·2	70·6	1·285	.....	1·263	1·68	,,	,,
6.	3·205	24·8	79·5	1·972	2·158	2·106	2·81	,,	,,
7.	3·025	26·8	81·1	2·174	.....	2·392	3·19	,,	,,
8.	2·62	32·2	84·4	2·718	2·888	2·780	3·71	,,	,,
9.	2·43	34·5	83·8	2·894	.....	3·370	4·49	,,	,,
10.	2·28	37·1	84·6	3·138	2·903	3·538	4·72	,,	,,
11.	2·08	42·0	87·4	3·671	.....	3·960	5·28	,,	,,
12.	1·345	64·0	86·1	5·510	5·349	5·777	7·70	654	(Strap slipping.)
13.	2·08	41·1	85·5	3·514	.....	3·790	5·05	698	13° extra lead of brush.
14.	2·07	36·0	74·5	2·682	.....	2·852	3·80	696	8° less lead of brush than in original position.
15.	2·09	42·7	89·2	3·809	.....	4·233	5·64	708	5° ,, ,, ,, ,,
16.	2·09	41·7	87·2	3·636	.....	4·135	5·51	713	5° ,, ,, ,, ,,
17.	2·10	45·0	94·5	4·252	.....	4·810	6·41	759	5° ,, ,, ,, ,,
18.	2·08	40·8	84·9	3·464	.....	4·010	5·35	696	5° ,, ,, ,, ,,
19.	2·06	35·1	72·3	2·538	.....	2·672	3·56	586	5° ,, ,, ,, ,,

The principal object of the experiments was to ascertain how the electromotive force depended on the current. This relation is represented by the curve of Fig. 4, in which the abscissæ represent the currents flowing, or the values of Q in the table, and the ordinates the electromotive forces, or the values of E reduced to a speed of 720 revolutions per minute. The curve may also be taken to represent the intensity of the magnetic field. It will be remarked that there is a point of inflexion in the curve near the origin. The experiments 1 to 5 indicate that this is the true form of the curve, and it is confirmed in a remarkable manner by a special experiment. A resistance intermediate between 5½ and 4 was used in circuit, and E and Q were determined in two different ways: first, by starting with an open circuit, which was then closed; secondly, by starting with a portion of the resistance short-circuited, and a very powerful current passing, and then breaking the short circuit. It was found that E and Q were four times as great in the latter case as in the former. Unfortunately the numbers are not sufficiently accurate to be given, as the solutions of the standard battery had become mixed.

FIG. 4.



The curve really gives a great deal more information than appears at first sight. It will determine what current will flow at any given speed of rotation of the machine, and under any conditions of the circuit, whether of resistance or of opposed electromotive forces. It will also give very approximate indications of the corresponding curve for other machines of the same configuration, but in which the number of times the wire passes round the electromagnet or the armature is different.

It will be well to compare these results with those obtained by others. M. Mascart worked on a Gramme machine with comparatively low currents: he represents his results approximately by the formula

$$E = n(a + bQ),$$

where a and b are constants. This corresponds to the rapidly rising part of the curve of Fig. 4. Mr. Trowbridge with a Siemens machine obtained a maximum efficiency of 76 per cent., and states that the machine was running below its normal velocity. Mr. Schwendler's results, when fully published, will probably be found to be the most complete and most accurate existing. In the *précis* he states that the loss of power with a Siemens machine in producing currents of over twenty Webers is 12 per cent. Now, taking the author's experiments 4 to 19, the mean value of W_1 is 3·027 and of W_3 3·304; adding to the latter 0·21, the power required to drive the machine when no current passes, it appears that 13·8 per cent. of the power applied is wasted. Again, taking experiments 4, 6, 8, 10 and 12, the mean value of W_2 is 2·888 and of W_3 3·076, indicating a waste of power amounting to 12 per cent. Of this, as already stated, 0·28 horse-power is accounted for by friction of the journals and commutator brush; the remainder is expended in local currents, or by loss of kinetic energy of current when sparks occur at the commutator.

The author has not yet tried any quantitative experiments with the electric light, but hopes shortly to do so. In the meantime he would remark that, as the lamp is usually adjusted, only half the energy of the current appears in the arc, or 44 per cent. of the energy transmitted to the machine by the strap.

In conclusion the author would express the obligation he is under to Messrs. Chance Brothers and Co. on account of the facilities he has enjoyed for making these experiments at their works. It may be mentioned that one principal object of the research of which this is a beginning is to obtain a minute knowledge of the electric light, with a view to lighthouse illumination.

THE ROYAL SOCIETY.—At the annual *conversazione* of this Society on Wednesday, April 30, at Burlington House, among other interesting pieces of apparatus exhibited was a simple device by Dr. Shettle, showing a new method of investigating the lines of force in bar magnets. Some of the results obtained by Dr. Shettle during his investigation are entirely novel, and we trust will soon be published in a connected form. Mr. E. B. Bright exhibited his ingenious and simple self-acting electric fire-alarm. Messrs. Preece and Stroh showed the apparatus with which they are carrying out their experiments in vowel sounds.

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THE ELECTRICIAN.

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CHEAP TELEGRAPHY IN AMERICA.

We have before us a little pamphlet of fifty pages describing "what is to be" under the auspices of a newly-formed company called the "American Rapid Telegraph Company." The reading of this pamphlet recalled most vividly to our minds the words of another American author, who inquires through the mouth of truthful James:—

> Are things what they seem?
> Or is visions about?

Hitherto we imagined that we had at least a casual acquaintance with electrical theory and practice, but we are now promised such a thorough revolution in all that pertains to the application of electricity in telegraphy, that we begin to doubt if we ever understood the simplest facts of the science. Our telegraph department has prided itself upon being the equal, if not superior to that of any other country, but it must part with its laurels if one half of the statements in this pamphlet are true. It is not, however, the habit of scientific men to come too hastily to conclusions, and therefore, whilst hoping that the promises of this company may be fulfilled, we prefer to wait for practical accomplishment before giving allegiance to them. The poet we have previously quoted is not far from expressing our thoughts when he writes:—

> How many things I took for facts,
> Icarus and his conduct lax,
> And how he sealed his fate with wax!
> Avitor!

Facts "to be" are one thing, facts proved and acknowledged are another.

This new company, according to the pamphlet, differs from all others. It possesses patent rights giving it the sole control of an entirely new system of machine telegraphing superior to the ordinary systems in speed, accuracy, reliability and simplicity. "It will use only *cast steel copper-plated* conducting wires; steel having threefold greater tensile strength, and deposited copper, chemically pure, having sevenfold greater electrical conductivity than iron." An assumption is made that "three of these low-resistance wires" will transmit and receive a far greater number of messages than is now transmitted over the principal lines in the States. The statement that copper-coated steel wire has less than one-third the resistance per mile of iron wire is, we believe, hardly in accordance with experimental data. The resistance per mile of any wire depends not only on the material, but also upon the sectional area, and it may be that the copper-coated wire to be used is larger in diameter than the rival it is to succeed. At any rate, with a given section of steel it is easy to calculate exactly how much copper must be deposited on the wire to reduce the resistance to a given standard. The eighth section dealing with the peculiar features of this company, is a little surprising. We are accustomed to read circulars *cum grano salis*, but here the salt must be in bulk, not in minute quantities. The company has, says this portion of the pamphlet, "an entirely new and extraordinary system of machine telegraphing, which has a reliable transmitting capacity of one thousand words, or more, per minute, over one wire, in telegraph circuits of 500 to 1,000 miles in length. It has a 'real duplex telegraphy,' by which one wire is made precisely as effective as, and even more convenient than, two wires can be in the hands of expert 'Morse' operators. This system is divested of all the complications of other 'duplex' devices, and admits of sending and receiving messages, simultaneously, from either end of a wire, and to or from any intermediate or way office, which cannot be done by any other known 'duplex' or 'quadruplex' system. Then there is a system of 'multiplex telegraphy' which allows, in any circuit of 1,000 miles, of four messages—from both ends—simultaneously—thus, practically, duplexing the 'quadruplex.' The company has also a new system for working long ocean cables and underground telegraph lines, whereby the wires are discharged of all inductive and static electricity, and placed in a condition to carry electric impulses with twentyfold greater rapidity than heretofore, and which will increase the hourly transmission over any good Atlantic cable from 1,000 to, probably, 10,000 or more words per hour. In the 'metrical system,' as this is called, every

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possible electrical signal indicates, reliably, a Roman letter, in print—thus saving, of electric signals, at least three-fourths, as compared with any other known system of cable telegraphing."

When speed is not in question lines and whole pages even may be telegraphed. A new generating machine is to do away with branch offices, and allow of messages being sent direct. It is on page 9 of the pamphlet that a ray of light strikes us. This new generator does away with the necessity of "reperforating" messages, and we are inclined to ask what is the relation between this so-called new machine, and Wheatstone's well-known instrument. Has that been rediscovered by an enterprising American cousin, and is this new company the outcome of the discovery? Be that as it may we confess to a little scepticism when we read that "there has been no visible improvement in the last quarter of a century in the building of telegraph lines; in the insulation of the wires; in the wires themselves; or in the skill, accuracy, or rapidity of operating the same." It is amusing, too, to hear an American saying that "there has been no earnest desire and no successful attempt to introduce mechanism in aid of telegraphy." Recent articles in American papers have given us to understand that of late years a great deal has been done, and everything that has been done, with, perhaps, an unimportant minor exception or two, has primarily emanated from that side of the Atlantic. Now some of the American authors must be wrong. They can, however, decide among themselves which are the guilty parties; meanwhile, we are contented to watch carefully for the germs of real progress probably to be found under the mass of verbiage and boasting which herald the advent of the new company. If the wonderful machine is an improvement on Wheatstone's automatic machine, as the employment of perforations would seem to indicate, we shall, no doubt, soon hear something of it from our own telegraph department.

CORRESPONDENCE.

THE ENERGY STORED UP IN AN ELECTROSTATIC CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I gather from Dr. Lodge's letter under this heading that we are quite in agreement as to the potential of a *charge*, of the bounding surface on which the charge is distributed, or of any *point in such surface*, being expressed by the equation $V = \frac{2W}{Q}$, in which V is the potential as above, W the energy stored up in the charge, and Q the quantity in the charge. Many of your readers, probably, will be glad to have so simple an expression for "potential," and one in which we may recognise our old friend "tension." And I think it will be admitted that this expression may be taken as a *definition* of the tension (or potential) of a *charge*, of the *surface* on which the charge is accumulated, or of any *point* in this surface; although, as Dr. Lodge points out, there is a logical objection to its being taken as a definition of potential in the abstract.

I have to admit that the letters Q.E.D should have been placed after the sentence in italics preceding the final sentence in my letter. It would appear, in fact, that the proposition stated in this final sentence, viz.: That *the tension* (or potential) *of a point or surface is simply that of the static charge accumulated at the point or surface*, remains to be demonstrated; since Dr. Lodge, and "modern electrical theory," consider it to be "wholly and utterly false." I must, however, assume—as I have done above—that this proposition would be admitted *as perfectly true* in the very important case of a bounding surface on which a charge is distributed, or of any point in such surface; for I surely cannot be wrong in crediting modern electrical theory with a knowledge of the fact that there can be no difference of potentials between two points in conductive contact without the production of a current tending to neutralise such difference. There remain the two cases:—1, of a point or a surface *outside* of the bounding surface, or *between* the two opposing surfaces charged by a source; and, 2, of a point or surface *inside* the bounding surface, *i.e.*, completely surrounded by it. The latter of these cases I think I have sufficiently disposed of in my letter of March 1, p. 175. The enclosed point or surface *is not in the circuit*; it is as completely abstracted from any electrical influence as if it were at an infinite distance from any point in the circuit. When we speak of its tension or potential we mean—unless we have entirely lost sight of any physical significance in these terms—the tension or potential it obtains whenever we render it possible for a branch path of electrical propagation to pass through such point or surface, *i.e.*, whenever it is no longer completely enclosed within a conductor. In this sense only may a point or a surface *have any potential you please without there being the least particle of charge at either*. The exact analogue, in the conductive circuit, to such an enclosed point or surface would be a wire hanging loosely to the insulated conductor uniting the poles of a source. In the dynamical consideration of the circuit we have absolutely nothing to do with this wire, *it is not in the circuit!* If we spoke of the electromotive force acting through it, dynamically, we could mean only that which would become active whenever it became possible for a derived circuit to pass through this wire. The latter might have any conducting capacity you please, without there being the least particle of current passing through it.

In regard to case 1; let us *suppose* that a point or a surface may have any potential we please, without having any charge. We will give to the point or surface the potential + 10 volts; and, by means of a wire, terminated by a point or flame if necessary, we will bring it into conductive communication with earth. Then the difference of the potentials at the two ends of our wire will give an initial electromotive force of 10 volts acting through this conductor. But the existence of a difference of potentials necessarily implies the passage of a current through the wire, from the point or surface to earth, or *vice versâ*. And the electricity passing in the current must represent a free charge, *plus* or *minus*, located at the point or surface brought into contact with earth. But we have supposed that the point or surface at the potential 10 had no charge. *Quod absurdum est.*

We know that all conductors, and the molecules of all dielectrics, in the path of an inductive circuit become polarised, obtaining an induced charge opposite in sign to the inductric charge, and an inducteous charge of the same sign as the latter. The inducteous charge of each mass or molecule constitutes an inductric charge in relation to the next mass or molecule in the path of inductive propagation. It may be said, and perhaps Dr. Lodge would say, that a polarised mass or molecule has no charge, since the induced and the inducteous charges are equal. But he will perceive that what I call "the static charge accumulated at the point or surface" is the inducteous charge—that which, in the case at least of a polarised conductor, gives an electrometric indication. It is this free charge which gives to the point or surface its electrostatic tension or potential. By conducting it to earth, work is done, and an equivalent quantity of energy disappears from that which was originally stored up in the given charge. Now if we call Q the quantity passing to earth, and W the mechanical equivalent of the heat produced by the passage, the potential V of the point or surface will be given by the above equation. If this be true, and I imagine that Dr. Lodge can verify the proposition, mathematically, far more readily than I could by experimental facts and arithmetic, then *the potential of a point or surface is simply that of the static* (inducteous) *charge accumulated at the point or surface in question.* Q.E.D.—Yours, &c.,

DESMOND G. FITZGERALD.

THE CAPACITY OF A SPHERE IN SPACE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The expression $\frac{r\,r_1}{r_1 - r}$, for the capacity of a sphere placed concentrically within another hollow sphere of conducting material, has been verified experimentally; and it of course follows that, when the distance between the spheres is infinitely great, the capacity must vary as the radius of the enclosed sphere.* But it is precisely on this expression that I rely for the proof that the capacity of a sphere in space cannot vary as its radius. For it cannot be assumed, I think, that the surface of such sphere is necessarily, or ordinarily, surrounded by an opposing surface varying in a ratio greater than the square of the dis-

* The student will perceive that, when the radius r_1 of the hollow sphere becomes infinitely great, $r_1 - r$ may be taken as equal to r_1, and will thus cancel r_1 in the numerator.

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tances between the surfaces, or that one of the opposing surfaces becomes infinitely great when the distance between the surfaces is infinite. And it is in this case only that the charging capacity of a sphere varies as its radius. I object to the expression heading this letter, because it ignores not only the dimensions but the existence of an opposing surface from or to which a transfer of electricity must take place when the sphere is charged.

Considering the analogy which no doubt exists between the case of a conductive circuit completed by means of *earth plates*, at a vast distance apart but united by what may be considered as a "boundless conductor," and the case of an inductive circuit constituted by a source of which the poles are connected to conducting surfaces at a vast distance apart but immersed in a "boundless dielectric," I am inclined to withdraw my statement that a conductor at an infinite distance from another conductor would theoretically have *no charging capacity* if the poles of a source were respectively connected to these conductors. Cannot some of your mathematical contributors throw a little new light on this question?—Yours, &c., DESMOND G. FITZGERALD.

"THE NEW THEORY OF TERRESTRIAL MAGNETISM."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I heartily join in the thanks which your readers will accord to Professor Ayrton for his further contribution to the subject of this new theory. As an answer to my inquiry, however, I cannot regard it as satisfactory. I asked for information, and Professor Ayrton begins a controversy, the advantage in which is all on his side, seeing that he has his (still unpublished) paper in his mind, while we have but the, apparently, inadequate exposition of it by Dr. Muirhead. It was upon this latter that my question was based, and as Dr. Muirhead has not replied, it is obviously no use controverting a position which Professor Ayrton himself might repudiate. In these circumstances we must wait the publication of the paper.

Meanwhile one's sympathies are gradually being drawn towards the much abused *Engineering* critic. One exercise of the critical function is to elicit plain statements, to put a possibly tenable opposing view in a pithy and intelligible shape—to push in fact a new theory to its logical, and, if need be, its absurd, conclusion. The *Engineering* critic appears to have said, "If Professor Ayrton's theory were true an electrified bar of iron in rapid rotation would become magnetic." Professor Ayrton treats my cart wheel more respectfully, but really it tells the same tale. Probably the thought in the critic's mind, as it certainly was in mine when I, quite independently, selected a wheel as illustrating our difficulty, was that if the theory involves this much, why is it not tested experimentally forthwith? Professor Ayrton's answer is that the *reductio ad absurdum* will prove prophetic. I, for one, hope it may; but that mode of answering is begging the whole question. *Will* the bar become magnetic, that is the question; *will* an electrified felloe magnetise its nave? If so, why are we not told that it *does?* Taking, in the words of Dr. Muirhead, "a solid sphere of iron the size of the earth," or assuming as does Professor Ayrton "the rotation of particles round their own axes," are modes of reasoning of supreme value only where matter of fact experimental test is not practicable. The question whether it is practicable or not in this instance is precisely what we want to get answered, but no answer is forthcoming.—Yours, &c.,

April 26th, 1879. J. LAISTER.

ELECTROSTATIC POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly allow me briefly to answer Mr. Cumming's objections?

1. I cannot find the *petitio principii* complained of: it is only assumed on ordinary mechanical principles that the electric force at all points on the surface of a charged body in equilibrium must be normal to it, as equilibrium could not subsist if there were a tangential component.

2. I see no difficulty in my definition of the electrostatic potential at a point; by "a body at a point" is meant "a body whose surface passes through the point." The expression "potential of P" should have been "potential at P."

3. I introduced dimensions merely to distinguish between quantities of different kinds: for two quantities, whose dimensions are different when measured on the same system, cannot possibly be of the same kind, though agreement in dimensions is no criterion of sameness—*e.g.*, length and electrostatic capacity. There is no paradox in the case quoted by Mr. Cumming; for the unit of mass is not a fundamental unit in the system adopted, but a derived unit of dimensions $L^3 T^{-2}$.

4. If v velocity-units is the velocity of a body, we may certainly say that v is not the velocity but its measure, and so on; this use, however, of the word *measure* is entirely different from that which occurs in my definitions.

5. As a mere mathematician, I can accept the definition of momentum as the product of mass into velocity; as a physicist I agree with Mill, and require the definition of momentum to declare its meaning, and, therefore, being quite unable to form any mental picture of such a product, I conclude that it is merely the measure of something of which a mental picture can be formed.

6. My definition of potential must certainly be modified in order to include gravitational and magnetic potential: but that it must be defined as a property which is measured in a particular way I have no shadow of doubt.

I quoted the definition of density from Mr. Cumming's book, merely because I had no other at hand: the same occurs in all text-books—in fact, on page 97 of my "Book of Heat" (which pretentious title is none of my choice, being suited to the series of which the book forms part) I find "density is the actual mass in grams per cubic centimetre," which I would now emend by inserting *measured by* after *is*.

I can only class Sir W. Thomson's definition of potential in § 335 of "Papers on Electrostatics and Magnetism," which was pointed out to me in your last number, with the other definitions I cited; for I read, "The amount of work required to move a unit of electricity . . . is equal to the excess of the electric potential . . ."—Yours, &c., ROBERT E. BAYNES.

Christ Church, Oxford.

QUADRUPLEX TELEGRAPHY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As Messrs. Briggs and Winter's representative, allow me to contradict Mr. Brough's statement, if I interpret his letter rightly, in your issue of April 19, that Mr. Briggs's split battery system of duplex, a modification of Heaviside's, is not in operation in India. I saw it working myself in the Government telegraph office at Madras last October, and in letters from India by last mail I am informed that they are working it now between Madras and Calcutta, Madras and Bombay, and Bombay and Calcutta, to the exclusion of all other systems.

I believe the relay, to be used in the system of quadruplex devised by Mr. Winter and myself, was shown to Mr. Brough in confidence. I can't understand how that gentleman came to write publicly of it in your journal without permission.

As soon as the final specification of the patent is out, I will have the pleasure of sending you a full description of the contents, which I hope you will allow to be inserted early in your journal.—Yours, &c., ALEX. MUIRHEAD.

29, Regency-street, Westminster, S.W., April 21st, 1879.

ELECTROSTATIC POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the remarks quoted p. 253, Dr. Hopkinson somewhat misconstrues my saying or meaning. I do not say that electrostatics and electro-dynamics are two distinct universes *to the mathematician*, but that those subjects, as developed by the mathematician, appear to ordinary common sense people to belong to distinct universes. The mathematicians do not belong at all, it would seem, to our universe, which is one of three dimensions. They do not deal necessarily with what *is*, but assume conditions to suit them, and have called into existence a universe of their own, which some of them find to have four dimensions. Nor did I say anything about electrostatic potential not turning up in electro-dynamical problems. Electrostatic actions do accompany electric currents in the form of inductive actions. But I do say that the artificial theory of static electricity has to be given up in dealing with current electricity, just as though these two electricities were distinct entities.

Both Professor Baynes and Mr. FitzGerald object to my proposition that electromotive force, or difference of potential, really means "square root of energy." I must refer them to an article on "The Constants of Current" for the development of that idea, which it seems to me must serve for the foundation stone of that physical theory of electricity, which Mr. FitzGerald desiderates. Here I will only say that I see nothing terrible in the consequence, indicated by Prof. Baynes, that it would "require potential to be electricity." To me electricity and magnetism convey no idea of any objective entities; they mean nothing but energy charged upon material molecules. I believe that they are fast following their relatives, phlogiston and caloric, to that Hades of dead phantasms—oblivion. Already the austral and boreal fluids of magnetism are lost even to

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memory; the vitreous and resinous fluids of electricity still retain some feeble vitality, but their days are numbered. Dissimulated electricity and surface charge are taking their places in the same sad procession. When I say that electric potential really means $\sqrt{\text{energy}}$, I convey the same truth which Mr. Cumming indicates, p. 259, from another point of view, that the definition of potential is that of a field of force. Just so, and why? Because electricity is simply energy,—in its static form, potential, charged upon the field of force included between the two surfaces, while the potential or tension is simply an expression of the square root of that energy (the same facts underlying Mr. FitzGerald's interesting demonstrations p. 261). In dynamic electricity, again, the energy is kinetic, doing work in the conductor; here electromotive force, or any term covering the same idea is also simply an expression of the energy supplied in terms of its square root. Thus the whole distinction between static and dynamic electricity resolves itself into that between an inductive circuit, in which energy can be stored, and become potential, and the conductive circuit, in which the energy is wholly kinetic and doing work.—Yours, &c.,

J. T. SPRAGUE.

CHARGE AND INFINITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The complacency with which Dr. Lodge regards his own adopted theory and with which he sets down the one of other people, p. 273, is really amusing. "The facts on which they base their opinion are true; the conclusion is not true (or, not to beg the question, we will say is not orthodox), therefore there *must be a flaw in their reasoning.*" That is all very well on the first assumption that the conclusion *is not true*. But that *is* the question itself, and the other side believes that there is the very best ground for holding that it is the conclusion of Dr. Lodge and his fellow believers which is not true. But *orthodox!!* Is it then an absolute fact that truth and orthodoxy are always identical? Perhaps the best definition of orthodoxy was that given by a witty divine—"Orthodoxy is my doxy and heterodoxy is anybody else's doxy." But the beauty of the thing is that Dr. Lodge first locates the flaw, in "their misconception of the nature of infinity," and then proceeds on the identical course which it is contended has led to the erroneous (orthodox or mathematical) conceptions of electricity. Why the infinity he defines (fancy a definition of infinity) is a mere myth, and no wonder the conclusions connected with it are somewhat mythical. We can form an idea of infinite space and infinite time, as the dwelling place and lifetime of God. We are compelled to the recognition of *these* infinites by the fact that the negative conception is impossible, we cannot even imagine a limit. But an infinity to the end of which we are required to conceive ourselves carrying something—an infinity which can be expressed by ∞ and which being multiplied "0 times may be anything you like," belongs to the mathematicians' universe, not ours. The doctrine offered us may be orthodox, but it is not true.

This artificial infinite means nothing more than a quantity, holding no comparable relations to other quantities under consideration, and consequently any argument or reasoning about its relations is of no physical value, and the use of it leads to fallacious results. Dr. Lodge admits that "the really active agent in electrostatic phenomena is the polarised dielectric." This means that all charge is of the nature of a condenser; it always involves two surfaces connected to and enclosing a dielectric in which a field of force is set up through the intermediary of the two coatings. Will he tell us how we are to conceive the bounding surface (and the connection to it), which encloses the infinite space upon which, he invites us to believe, resides "the equal opposite charge spread all over infinity?" It seems to my limited imagination that Professor Clerk Maxwell says very justly that "this point of reference is not conveniently accessible."—Yours, &c.,

J. T. SPRAGUE.

A SUGGESTED USE FOR THE PHONOGRAPH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A French gentleman, introduced by Dr. Siemens, showed a curious toy phonograph at the Society of Telegraph Engineers a fortnight ago, which I have not seen described* in your own or any other journal. Although not electrical, it may interest some of your ingenious readers. Besides, I have a suggestion to offer which they may try their hands at. Upon a piece of thin board were mounted several strips of metal looking like short lengths of flattened wire, with indented surface, representing phonographically such words as "Bon jour," "Victor Hugo," &c., &c. A cast had apparently been taken of the original indentations from the drum of a phonograph, and then been stereotyped into a permanent form. To enable these facsimiles to emit the corresponding sounds, the edge of a cardboard disc was drawn briskly along their surface. A wire (of lead, I believe) attached to this disc was fastened to the tip of a cardboard funnel, on applying which to the ear the words could be *heard*. If one had paid a shilling to hear them they might also perhaps have been understood.

Now for my suggestion. With suitable appliances we know that the sounds may be made much louder, and what I want is to turn the phonograph to some useful—useful, of course, including amusing—account. For example, as an alarum, or musical appendage to clocks. With a properly prepared drum attached to the clockwork, one might be awoke of a morning with airs that would make early rising endurable; or, if preferred, a curtain lecture could be introduced which would make staying in bed intolerable. Again, the well-known Trumpeter who comes out of certain Swiss clocks every hour of the daytime might deliver himself at much less cost than his present mechanism entails. A diaphragm with a style attached to it pressing upon the drum would do the business cheaply, and, one would think, quite admirably. If anybody likes to try it he is welcome to the idea, providing he does not try to patent it as well. The public has paid more than enough for the phonograph already.—Yours, &c.,

SAM SLICK.

22nd April, 1879.

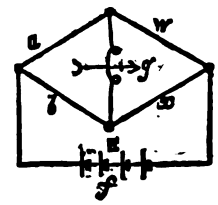
* M. Hospitallier was kind enough to show us his ingenious toy on his arrival in London, but as it was not electrical we could hardly give a description of it in our columns. It has been described in our contemporary, *Engineering*.—ED. *E.*

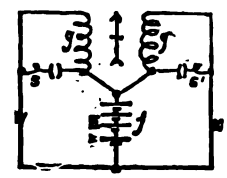
EARTH CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The writer who reviewed Mr. Schwendler's "Testing Instructions" in *Nature* of the 2nd January, 1879, was appalled by the expressions given for eliminating the influence of a natural current in the unknown resistance, when measuring with a differential galvanometer. These formulæ can, however, be reduced to the same degree of simplicity as those applicable to the bridge, with which, *mutatis mutandis*, they are, in fact, identical.

The following figures will be understood without explanation:





Let n and n' denote the multiplying power of the shunts s and s' of the differential galvanometer, *i.e.*, let $n = \frac{s+g}{s}$ and $n' = \frac{s'+g}{s'}$. Further, let e denote the foreign electromotive force in the unknown resistance x. And, lastly, let w' and w'' be the two resistances producing balance when we measure with reversed currents. Then

$$e = \mathrm{N}\,\mathrm{E},$$

and

$$x = k\left(\frac{w''+w'}{2} - \mathrm{N}\,\frac{w''-w'}{2}\right).$$

Where

$$\mathrm{N} = \frac{k\,\frac{w''+w'}{2}}{k\,\frac{w''+w'}{2} + (1+k)f + b}.$$

In the case of the bridge, k stands for the ratio of the branch resistances, *i.e.*, $k = \frac{b}{a}$, and b is the resistance of the branch lying next to the unknown resistance x. In the case of the differential galvanometer, k stands for the ratio of the multiplying power of the shunts, *i.e.*, $k = \frac{n}{n'}$, and b represents the parallel resistance of the galvanometer coil and its shunt lying next to the unknown resistance x, *i.e.*, $b = \frac{s'g}{s'+g}$.

These formulæ are sufficiently simple for practical purposes, and they are further simplified when we test with equal branch

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resistances in the bridge, or without shunts in the differential galvanometer, as then

$$k = 1,$$

$$x = \frac{w'' + w'}{2} - N\frac{w'' - w'}{2},$$

and

$$N = \frac{\frac{w'' - w'}{2}}{\frac{w'' + w'}{2} + 2f + b}.$$

I may add that Mance's method of measuring a resistance containing an electromotive force is just as applicable to the differential galvanometer as to the bridge.—Yours, &c.,

Alipore, Calcutta, 27th March, 1879. R. S. Brough.

PROPOSED NEW ATLANTIC CABLES.

The following would seem to indicate that the promoters of the new French cable are not likely to find their plans work as smoothly as they anticipated:—

London, 30th April, 1879.

To the Syndicate and intending Subscribers to "The Compagnie Française de Télégraphe de Paris à New York."

I beg to submit to your best consideration the following points concerning this enterprise:—

1st. In December, 1874, the Count Dillon, who then, as he does now, represented M. Pouyer-Quertier, entered into contracts with me, through which the present scheme was originated, and under which I now claim:—That any organisation brought out independently of me, as is the case with the present, is inoperative without my consent. And, further, that in consideration of the withdrawal of my application for a concession from the French Government, then before the Duc Decazes, I was to receive one-half the remuneration received, less the payments I was to make to the Count Dillon and others, and the concession was to be received in the joint names of M. Pouyer-Quertier and myself.

2nd. The Act of Congress of 1867, under which you propose to lay your cables, is understood by the United States Government to apply only to cables laid *viâ the Azores*, and, this being so, it is evident that the right, which you allege you possess, to lay cables by the route you name from England and France is wholly worthless.

3rd. There must be some mistake in regard to the statement circulated that you will lay your cables in connection with a complete land-wire system in the United States, as it is well-known that the Anglo-American Company and Direct United States Company have the control of and an intimate working connection with the land systems of the Western Union and Atlantic and Pacific Companies, whilst I control under special arrangements the land wires of an independent system, of which important railroad wires and independent wires now progressing are the nucleus, and in connection with which I own the Act of Congress of 1877, under which cables can now only be laid in the United States without any question.

4th. The prospectus does not clearly state the nature of the concession you hold from the French Government, but, supposing it to be in your favour, you cannot lay a cable under it to the United States, as under the administration of President Grant and Secretary Fish it was distinctly understood that no cables from France would be allowed to be landed on the shores of the United States under a second concession to a foreigner, but that the concession must be in the name of an American citizen or corporation in order to meet the demand for reciprocity established by the said administration, and in the absence of special action in Congress as to French cables this policy will be maintained by President Hayes and Secretary Evarts.

5th. It would appear that the capital asked for is largely in excess of the real requirements of the enterprise:—

The amount proposed to be raised in Shares and Bonds is	Fcs. 52,000,000
Add premium of 2½ per cent. on Shares issued by the Syndicate—for what reason is not stated	5,250,000
Making in all	57,250,000
But two cables—from the Continent to the United States—superior in every way to any hitherto made, can be laid at a cost of say	37,000,000
Leaving unaccounted for	Fcs. 20,250,000

but which seems to be excess of capital.

Would it not be wise for Cable Stock Subscribers to wait the announcement of a new French Cable Company who propose to manufacture their cables in France and to ask for 300 francs a share—*not* 512·50 *francs*—with which to lay two cables, equal to your two proposed cables?

6th. Supposing that your combination overcomes the very many serious difficulties which I have pointed out, and gets into working order, the only result, if the present tariff is maintained, which is not at all likely if you attempt competition, will be the absorption by the Anglo-American Company of your enterprise at half its original cost. When the Direct United States Company became a real competitor the Anglo-American Company reduced the tariff to 1s. a word, and within a few weeks their friends and allies obtained the whole control of the Direct Company, and the loss to the shareholders of that Company from the issue price of their shares is at the present moment about £700,000.

7th. It is my purpose to establish all my rights as above indicated, under the laws of France, England, and the United States.

W. Cornell Jewett,

Of United States of America, Concessionaire, &c.

MOMENTARY CURRENTS IN WIRES.

BY F. C. WEBB, M.I.C.E.

(continued from page 275.)

When the wire is in the form of a coil we have another effect produced. On making contact with the battery the current at the distant end takes more time to arrive at its maximum, and, on breaking contact and placing the near end to earth through the galvanometer, instead of the deflection being reversed to what it was during charging, it will continue in the same direction, indicating a current in the same direction as the primary current. This current will in duration and strength depend on the size of convolutions of the coil and on their proximity. The most marked case the writer has observed was in some seventy miles of hemp-covered cable, coiled dry, on board the steamship Elba. This was part of a cable intended to be laid between Candia and Alexandria. Here the current kept the needle of a common vertical galvanometer over for some twenty seconds. This current is that described by Faraday as the induction of a current on itself, and is said by the higher electricians to be due to an electro-magnetic effect. It is also called the extra current. It first came under the writer's notice in cables in 1856, when testing pieces of the Hague wire-covered cable on board the Monarch. He then called Mr. Latimer Clark's attention to it, and in 1859 called attention to it in a letter in the *Engineer*. The current is said to exist even in a straight wire, though to a less degree.

As the effect is the reverse to the discharge it has also been termed "*false discharge*." It is evident, that as the effect is reverse to the discharge, that we may, if the wire is coiled and has great electrostatic capacity, have the two effects in antagonism. Thus a gutta percha wire, coiled and immersed in water, has the conditions for both the discharge and coil current, and in some experiments made by the author at the Gloucester-road works, in 1859, on three coils immersed in water, both currents were visible. By "a sharp tap down of the key and let go" we could always get the coil current, and "by a slow tap down and hold down" (thus run my notes) we could always get a return current. Could always keep the needle over to 45° on either side, by doing these peculiar taps in succession. Unfortunately I have no note how the key was arranged, but it is evident that the effect of the two currents was visible.

This effect produced by the coiled state of a wire used to interfere considerably with signalling between ships and shore, and in the laying of some of the earlier cables it was found difficult to speak until some of the cable was paid out. We do not hear much of it now. I have asked some of the electricians employed in laying our long lines, and they do not appear to have been inconvenienced by it. Nor do they notice it in testing, as there is no test they take where it could be noticed. As a matter of scientific knowledge it would be interesting if some experiments to observe it were made. It is quite possible that the greater space between the convolutions of the conductor caused by the increased outer diameter of the present cables may lessen the effect. The cables being now also immersed in water in the ship, and having wet serving, instead of being coiled dry and having dry serving, may by increasing the electrostatic capacity tend to obliterate this effect of electro-magnetic induction by the effects of the discharge of the static charge.

Another momentary current in a submarine cable on board ship is caused by the rolling of the ship. The coil being moved in a magnetic field, an electro-magnetic effect is produced, and a short

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momentary current is the result. This current was first observed by Messrs. Siemens' staff during the laying of the cable between Kurrachee and Aden in 1859, and some careful observations were also made on it by Mr. J. Woods, in one of the sailing cable ships that carried the Persian Gulf cable round the Cape to India in 1863.

(TO BE CONTINUED.)

NEW TELEGRAPH CABLE SHIP, "PATRICK STUART," FOR THE PERSIAN GULF CABLE.

In the very early days of submarine cables many lines that might have been repaired and maintained were abandoned through the want of a proper repairing ship, as when a fault occurred not only the delay in hiring and fitting out a ship allowed time for further accidents, thus complicating the work, but the great cost of this step, unprovided for by any capital being specially laid aside to meet the contingency, and coming when all receipts were stopped, generally ended by swamping the whole financial arrangements of the company. The Electric and International Telegraph Company, in 1853, having bought a steamer for laying their submarine lines, soon found that she was a necessity for the maintenance of these cables, and the old Monarch became the first example of a regular telegraph cable repairing ship.

About the next permament cable repairing ship was the Amberwitch, fitted out in 1863 for the Indian Government Indo-European line in the Persian Gulf. Since then the Anglo-American, Eastern, Eastern Extension, and many other companies have found it necessary to have their own repairing ships, and altogether, including the ships belonging to contractors, there exists about sixteen of such ships. It is curious that the only large telegraph administration, having cables, that does not possess a cable ship of their own is H.M. Post Office Telegraph Department, who possess sixty-two cables, and who succeeded to the Electric Telegraph Company in the possession of the first repairing ship, the Monarch, which ship has long since been condemned, and never replaced, the consequence being that the Government have to hire special ships at great cost.

We have now, indeed, arrived at what may be termed a second generation of cable ships, for the Anglo-American have replaced the Robert Lowe by the Minia, the Eastern Extension have replaced the Edinbro' by the Sherard Osborne, and now the Indian Government are about to replace the Amberwitch by the Patrick Stuart, which ship was bought on the stocks by the Indian Government, and completed to the designs of their officers.

Most of our readers are aware that one of the telegraphic routes to India is *vid* Persia and the Persian Gulf. These Persian land lines and the Persian Gulf cables are maintained and worked by a staff separate from the Indian telegraphs proper. This department is termed the Indo-European Government Telegraph Department, and is under the direction in chief of Lieut.-Colonel J. U. Bateman-Champain, R.E., under whose immediate direction the land lines through Persia were constructed, in 1862 to 1864, and who, after acting either as acting director or assistant director-in-chief from 1865 to 1870, has filled the post of director-in-chief since 1870, when he succeeded General Sir F. Goldsmid, K.C.S.I. The Persian lines and Persian Gulf cable were projected by the late Lieut.-Colonel Patrick Stuart, R.E., and the control of the construction of the whole of these lines was entrusted to that officer whose courage, energy, and skill during the the Indian Mutiny had won for him the confidence of Government and the esteem of all who were associated with him or who had acted under his orders. He died at an early age at Constantinople, partly through overwork, just as his arduous work was completed. A memorial window in Kurrachee Church bears record of the feeling of the Staff towards him; and the name given to the new repairing ship is another graceful tribute to his memory from those who had authority in the matter.

The ship has been completed and fitted under the superintendence of Colonel Champain, assisted by Lieutenant Stiffe, the engineer to the Persian Gulf cable, who has had 14 years' experience in the Gulf in charge of the line.

On Friday, at the invitation of Lieut.-Colonel Champain, the new ship, which arrived in the Victoria Docks from Scotland a few days ago, was inspected by some of the members of the Indian Council as well as several gentlemen connected with telegraphy. Amongst these visitors there were Sir W. Mercewether, K.S.I.; Sir Barrow Ellis, K.S.I.; Sir H. Norman, K.C.B.; Colonel Yule and A. Cassels, Esq., members of the Indian Council; W. Thornton, Esq., C.B., Secretary to Public Works Department; and Colonel Johnson, Military Secretary of the Indian Government; and Major-General Sir Frederick Goldsmid, C.B., K.C.S.I., formerly Director-in-chief of the Indo-European Telegraph Department; Mr. J. Mac Donald, Sir C. Bright, Mr. Latimer Clark, Mr. Graves, Mr. W. H. Preece, Mr. Matthew Gray, Mr. C. Siemens, Captain Trott, Mr. F. H. Webb, Mr. Greener. As the visitors arrived they were received and shown over the ship by Col. Champain and Lieut. Stiffe, and then broke up into knots, and as some ladies graced the day by their presence, the ship, with her bright spick-and-span look, dressed with flags, and with her Lascar crew in their picturesque costume, had quite a gala appearance. Refreshments were served in the saloons, which are cheerful, and well lighted and ventilated.

The ship was built and engined by Messrs. John Key and Sons of Kircaldy, on the Frith of Forth. She is classed 100 A 1, or the highest class at Lloyd's. Her tonnage under deck is 872 gross, but including poop and houses is 1,130. She is 235ft. extreme length, breadth 30ft. 6in., and depth of hold 16ft. 6in. She has a full poop, 136ft. long, and forecastle 34ft., and has a lower deck 86ft. for the accommodation of the crew. She has an iron main deck, covered with teak.

The engines, which are compound, the cylinders being 28in. and 54in. diameter, and the length of stroke 33in, are of 130 nominal h.-p. The screw is 13ft. diameter, and 14ft. pitch. She has a speed of about 10 knots.

She has four cable tanks, varying from 24ft. to 28ft. diameter, and capable of holding 170 miles of cable of the Persian Gulf type. These have iron cones which are arranged as fresh-water tanks.

She has water ballast tanks over the whole of her main and after hold, which will contain 160 tons of water, and will enable the ship to be trimmed as required, a great desideratum in a cable-repairing ship where the disposition of the cable in the tanks has so often to be altered. These tanks also give additional safety, as they form a second bottom to the ship. The whole ship is divided into seven water-tight compartments. The coal bunkers will hold about 160 tons, or sufficient for about twenty days full steaming. She has cabin accommodation for a telegraph staff, with bath-rooms, store rooms, and battery room, and the deck houses will accommodate the director, electrician, and provide a testing room, &c.

A condenser for supplying fresh water is fitted, and water tanks for the stowage of 7,500 gallons of fresh water are provided. There is a separate powerful pumping engine for pumping out the ballast tanks, which is also arranged to pump out the ship, or can be used as a fire engine. This pump will throw 150 tons an hour. Another separate donkey pump is fitted to pump out the cable tanks, and a third donkey pump for the feed. Chadburn's patent repeating telegraph to helm and engine room, as supplied to the Royal Navy, have been fitted from bridge, and forecastle, the latter for cable work.

The vessel is fitted with bow and stern sheaves, but the picking-up gear and paying-out break will be taken from her predecessor, the Amberwitch. The ship has been provided with a Siemens Brothers' Electric Light apparatus, to enable the work of finding buoys, &c., to be better carried on at night when necessary. She has also a special crane for lifting in buoys, and by which the anchor can be lifted from the waters' edge to the forecastle without any catting or fishing. Sir W. Thomson's compass is fitted as a standard compass, and the vessel has a steam steering gear and steam windlass, and Trotman's anchors. Altogether, the ship seems in every way well adapted to her work, and no pains seem to have been spared to render her complete, and to take advantage of all the latest improvements that can facilitate the duties of those who will be engaged in her. Lieut. Stiffe takes the ship to India, and then resigns his post to take up that of master attendant at Calcutta, and the department will thus lose the services of a very zealous and efficient officer, who has done good work during sixteen years' service.

The ship was selected with the advice of Mr. Dunn, of the Admiralty, and to Mr. Logan, of the Admiralty Construction Department, the greatest credit is due for constant and most efficient supervision of the work while carrying out Lieut. Stiffe's arrangements. Mr. Hannaford, formerly Chief Engineer in the Indian Navy, was also employed superintending the engine work, &c., &c.

The Persian Gulf cable, laid under the superintendence of Sir C. Bright and Mr. L. Clark, from the first not only had the advantage of a repairing ship, but also of a proper cable yard with six cable tanks under sheds, and proper store-rooms, &c., erected at Kurrachee from the designs of Mr. F. C. Webb, who had engineering charge of the line for the first year after construction, and organised the first repairing arrangements.

Lieut. Stiffe, who commanded the Amberwitch from the first, has, for the last fourteen years, filled the post of engineer to the department, and under his direction many important deviations and improvements in the line have been carried out, comprising the shifting of a station from one side of the Gulf to the other, which involved the lifting and relaying of much cable. During the directorship of General Sir F. Goldsmid in 1869 a duplicate cable, 500 miles long, with Hooper's core, was laid between Jask and Bushire, under the supervision of Colonel Champain and Mr. L. Clark, assisted by Mr. Herbert Taylor, Mr. G. Preece, and Lieut. Stiffe. The establishment at Kurrachee has also for some time been supplied with proper machinery for coating recovered cable with canvass serving and pitch as in the newest type of cables, and the works are about to be supplied with closing machines for laying iron wires on to the old core, so that when the iron wire of recovered cable is much rusted, the core is stripped and re-covered with new wire. This is a step in the right direction, as every precaution that facilitates economical repair must lead to lines being steadily maintained, instead of the alternative of wholesale renewal or entire abandonment.

Altogether this line has been extremely well managed, and no doubt to General Sir F. Goldsmid, who directed it for some time, much is due, as also to the energy of Lieut. Stiffe, Mr. Mance, and others in the Gulf, and to Mr. Brasher, the traffic manager; but Lieut.-Colonel Champain has been connected with it from the first, and the judgment with which he has directed the whole, so as to maintain the line in a high state of efficiency as regards its working, as well as adopting every possible step to ensure its safe maintenance, reflects the greatest credit on his ability and energy, whilst his urbanity and kindness have won for him the esteem of the staff under him, and we heartily wish him some honourable recognition of his services, as well as success in the latest step for the safety of the line in the cable ship, "Patrick Stuart."

THE SOCIETY OF TELEGRAPH ENGINEERS.

On Wednesday, 23rd April, Mr. Adam Scott read a paper before this society, entitled "Recent Improvements in Bell's Telephone." It turned out to be, however, in the main a descriptive and illustrated account of Mr. F. A. Gower's loud sounding Telephone. Contrasting the enormous number —no fewer than 26,000—telephones rented and in daily use in America, with the 500 employed—or at all events rented—in this country, Mr. Scott thought that their unpopularity here was due to the inferiority of the instruments supplied, and to the difficulty of using them in places where absolute silence did not prevail. To remedy these defects Mr. Gower, who last year exhibited his Telephonic Harp before this society, had given much attention, and had succeeded in making an instrument which not only gave its own alarm call, but which both for speaking and receiving purposes allowed the operator to be some distance away from it. It could not easily get out of order; and conversation could be carried on in the midst of considerable noise—the audience in this instance putting the instrument's capabilities to a rude test by making a great uproar while the Chairman and Mr. Preece listened to what was being said at a neighbouring house in Great George-street. The playing of a cornet was heard all over the Theatre, and a cornet

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duet was singularly effective. The most striking feature about the new instrument was that it reproduced sounds originating several yards distant from the mouthpiece. Conversation carried on in any small room where such an instrument was placed would evidently be transmitted with much the same fidelity as by means of a microphone. Mr. Gower, holding the opinion that the stronger the magnet the better the results would be, had obtained a magnet the strength of which was altogether unique. It was to all appearance a simple horse shoe magnet, but of some peculiar make of steel, the preparation of which was at present a secret; and the specimen shown was said to be capable of bearing ten times its own weight. The shape, too, was peculiar, resembling a "horse shoe" much more than do the ordinary magnets so designated. Indeed a small horse shoe (off the hind foot), with its arms bent inwards, so as to bring the elbowed projections (the heels of the shoe) near together, fairly represents Mr. Gower's magnet. Upon these two projections are wound the coils, having a resistance of about 60 ohms. The whole is securely set in a round brass box, within the lid of which a stout diaphragm is firmly screwed; and, the magnet, being bent in the manner described, has its poles facing the centre of this diaphragm. In the lid proper may be screwed either an ordinary speaking tube, or a trumpet-shaped multiplier. A metallic reed in a little box soldered on the diaphragm itself serves as the alarum. On blowing into the tube, or, in its absence, into a hole in the case, a loud musical note is produced, which is repeated by the diaphragm, with equal loudness, at the other end—attributable partly to the original sound, partly to the mechanical vibration of the sending reed on its diaphragm. The instrument was intended to hang on the wall, and thus breakage of the flexible wire, a common cause of failure in the hand telephone, was avoided.

Mr. PREECE opened the discussion, and said that the true explanation of the wonderful demand for Telephones in America was to be found in the quite exceptional character of its domestic institutions, and in the scarcity of manual help in the shape of either male or female servants Where a telephone is really wanted it is as likely to be used in this country as elsewhere; but the fact was, its field of usefulness as a competitor against hand messengers and ordinary telegraphy was very limited. His own experience of what he regarded as the more perfect and handy telephone of Professor Bell, was that it was seldom used except for show: messenger or Morse communication proving more convenient, more congenial, and in certain circumstances more secret. He noticed that the dominant or fundamental in Mr. Gower's telephone was very conspicuous, one note coming out much louder than the rest wherever it occurred in the tunes that had been played. Attention to this peculiarity in every telephone would enable people to speak, pitching their voice to the dominant of the diaphragm, much more intelligibly than they usually do. He suspected that in Mr. Gower's as in other attempts to increase the volume of sound, distinctness was sacrificed to loudness. Mr. Edison's latest motographic telephone, recently exhibited by Professor Tyndal, was a case in point; and it had moreover the anomalous feature that, although the sounds could be heard far away from the instrument you had to remain close to it and turn a handle in order to make it speak. Such appliances though curious, ingenious, and instructive, were therefore of little practical utility. A great deal of controversy had been going on about the theory of the Telephone, Professor Bell, he believed, still holding the molecular theory. For himself he had always held that the cause of sound was the vibration of the diaphragm—this opinion however was a little shaken by the fact that the alarm box here soldered to the diaphragm did not interfere with its vibrations. [This difficulty was explained away later on by Lord Lennox.] In conclusion, Mr. Preece drew attention to the unreliability of all telephones for strict literal transmission of speech. The sibilations, for example, were not rendered at all; and no instrument yet contrived could signal intelligibly such a sentence as the following—"Would'st thou wish to be stung by a serpent twice?"

Major WEBBER thought that Mr. Preece had scarcely done justice to the most wonderful and valuable discovery of modern times. He believed that the time would come when the telephone would be generally in use on ordinary wires. Some trials with a carbon transmitter on a wire seventy miles long, and witnessed by him, had been most encouraging, the effects of induction being almost completely overpowered. He mentioned also a novel use to which the ordinary Bell's Telephone had been put by intelligent linemen in the Postal Telegraph Service when out in search of faults. A telephone was left joined up at the outgoing office, and the lineman from time to time, by arrangement, as he travelled down the line, connected a second telephone, which he carried with him, to the wire and earth, and thus kept himself informed about the fault. This the men had done entirely of their own motion, and to save their legs; but it saved the Department's time as well.

Lord LENNOX explained that the soldering of the reed box to the diaphragm would have the effect of altering the fundamental note, but not of impeding the vibrations. Some time ago he had constructed a telephone with a very large compound magnet and a heavy diaphragm; and what had struck him most, as it had the audience that evening, was the wide collecting power of such instruments. They were in fact practically microphonic. He could recognise the voices, though not always the words of any conversation going on in the room where his large telephone was placed, he with his receiving telephone being at the time half a mile away. He had found the telephone a great convenience, and in his case it had superseded the much slower A B C instrument which he had formerly used.

Professor AYRTON, referring to M. Ader's and Conte du Moncel's recent experiments on telephones without diaphragms said that neither his own attempts nor those of Mr. Latimer Clark, who was absent through illness, to verify the alleged effects had as yet been successful. Touching the indistinctness of articulation Professor Ayrton thought that the diaphragms would be more perfect if their redundant vibrations could be checked. A very small diaphragm did not collect all the sonorous waves; on the other hand a very large disphragm collected the waves at different points, and at different angles upon its whole surface which possibly led to confused articulation. He suggested the interposition of some viscous substance—say in the chamber between *two* diaphragms—as a possible corrective.

Mr. SCOTT in reply stated that the Company he represented considered a good test of a telephone's make was its distinctive articulation of the letters B and P, and T and D. His attention had never been drawn to its defective sibilation.

SUBMARINE CABLES TRUST.

The eighth annual meeting of the certificate holders of this Trust was held on Thursday, May 1, at the Cannon-street Terminus Hotel, under the presidency of Mr. J. Pender, M.P.—The Chairman said that the revenue had been £23,562 as against £22,298 in 1878, and the ordinary expenses had been £1,315 as against £1,303 in the previous year. Certain legal expenses had been in addition incurred, of which they had not yet received particulars, and other expenses connected with the formation of a limited liability company would have to be met, for which a suspense account had been opened amounting to £685. It was hoped that some of this might be accredited to revenue. After paying the expenses of the Trust and of twenty certificates purchased last September at a price of 94¼, there was a balance to the credit of revenue of £22.275. To pay the overdue coupon in full required £20,724, so they would have afterwards a sum of £1,551 to carry forward. The certificate holders were aware of the proceedings taken against all trusts which were formed some years ago under the auspices of the late Lord Westbury and other legal magnates, who had no idea whatever that they were not legally constituted, and their own solicitor was of opinion that this Trust was legally constituted. At the same time the authority and decision of the Master of the Rolls was a very important one, and as an injunction had been served on this Company that they could not deal with the funds till this question was settled, and as he did not think that it would be to the interests of the Company to fight the question on a point of law, they thought, as the Trust could be carried on on the same principles as a limited liability company, it would be much less expensive for the Trust to adopt that course. The principle in regard to this Company was much upon the principle of a tontine, and he thought that this was not a bad one. Their property was worth considerably more than it originally cost, and it was also worth more than the market value. They had received from the Globe Telegraph and Trust Company (Limited) an offer that they were prepared to accept the certificates of the Trust for their own shares—six Ordinary Shares of £10 each fully paid and five Preference Six per Cent. Shares of £10 each fully paid for each certificate of £100 each of the Trust. He moved, "That, in order to avoid all doubt as to the legality of the present constitution of the Trust, it is expedient to merge the Trust into a limited liability company, and that the trustees be requested to take steps accordingly."—Sir Daniel Gooch, Bart., M.P., having seconded the motion, it was adopted after some discussion, and the report was afterwards passed.—A vote of thanks to the Chairman and directors closed the meeting.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices April 30.		Business Done Week Ending April 30. Highest.	Lowest.
Anglo-American	56¾,	7¼	57¼	54¾
Do. "B"	85½,	6¾	86	84¼
Do. "A"	28½,	9	29½	26¾
Brazilian	6 13-16,	15-16	6¾	6 13-16
Cuba	8,	¼	—	—
Do. Ten per Cent. Preference	15½,	16¾	—	—
Direct Spanish	1¾,	2¼	2 1-16	1¾
Do. Ten per Cent. Preference	10,	¼	10¼	10¼
Direct United States ex div.	11,	¼	11¼	10¾
Eastern	7¾,	¾	7¾	7¼
Do. Six per Cent. Debenture	103,	6	102¾	—
Do. Five per Cent. do.	100,	3	102	101¼
Do. Six per Cent. Preference	11¾,	12	12	11¾
Eastern Extension	7 9-16,	11-16	7 11-16	7¼
Do. Six per Cent. Debenture	106,	9	109	108¼
German Union	7¾,	8¼	—	—
Globe Telegraph and Trust	4¾,	5	5	4¾
Do. Six per Cent. Preference	10 15-16,	11 1-16	11¼	10¾
Great Northern	8,	¼	8 3-16	8 1-16
Indo-European	20,	1	—	—
Mediterranean Extension	2¼,	3	2¾	2¾
Do. Eight per Cent. Preference	9½,	10	9¾	9¾
Reuter's	9½,	10¼	—	—
Submarine	220,	30	223½	222½
West India and Panama	1¾,	¼	1¼	1¼
Do. Six per Cent. Preference	8½,	¾	8¾	8½
Western and Brazilian	3¼,	4	3¾	3¾
West. Union Seven per Cent. 1st Mort.	114,	18	—	—
Do. Six per Cent. Sterling	102,	4	—	—

TRAFFIC RECEIPTS FOR MARCH, 1879.

Companies.	March 1879.	March 1878.	Incrse.	Decrse
Anglo-American Telegraph Company	47,550 estd.	—	—	—
Brazilian Submarine Company	13,052	14,239	—	1,187
Cuba Submarine Company	3,100 estd.	3,517	—	417
Direct Spanish Telegraph Company	929	880	49	—
Direct United States Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	26,185	23,112	3,073	—
Eastern Telegraph Company	41,225	38,201	3,024	—
Great Northern Telegraph Company	15,401	—	—	—
Submarine Telegraph Company	9,790	10,055	—	265

ROYAL ALBERT HALL.—EXHIBITION of ELECTRIC LIGHTING APPARATUS.—The Council announce that, in conjunction with the Society of Telegraph Engineers, they have arranged an EXHIBITION of ELECTRIC LIGHTING APPARATUS, which will be inaugurated, in the presence of H.R.H. the Prince of WALES, at the ROYAL ALBERT HALL, on WEDNESDAY EVENING, MAY 7, at 8.30 precisely, when a LECTURE on the general subject, with illustrations, will be given by W. H. PREECE, Esq.—Admission: Stalls, 3s.; balcony and other parts of the Hall, 1s. The exhibits will comprise most of the systems used in electric lighting, with the machines for their production in operation. The Exhibition will be held in the arena of the hall, and will remain on view until Saturday evening, May 10.

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NOTES.

BRAZILIAN CABLE.—The cable between Bahia and Rio de Janeiro is interrupted.

OLDEN TIMES.—In 1846 America boasted of 1,659 miles of telegraph line; in the middle of 1847 England had 1,056 miles.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The Company announce the repair of their Para-Maranham section.

THE CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).—The number of messages passing over the lines of this Company during the month of April was 2,672, estimated to produce £3,000, against 2,556 messages, producing £2,940, in the corresponding month of last year. The traffic receipts for the month of February, estimated at £2,800, realised £2,775.

A QUARTER OF A CENTURY AGO.—A return made by order of the House of Commons in 1843 stated that the annual expense to maintain the Admiralty semaphore signalling apparatus between London and Portsmouth was between £3,000 and £3,500. On December 31st, 1847, the semaphore system was worked for the last time, and then gave place to the electric telegraph.

DICKENS'S DICTIONARY OF LONDON.—According to this excellent little work, the telegraph offices in London which are open continuously day and night, both on week days and Sundays, are :—Central Telegraph Station, St. Martin's-le-Grand; Paddington Station (Great Western Railway Company), St. Pancras Station (Midland Railway Company), Victoria Station (London, Chatham, and Dover Railway Company), and West Strand.

CABLE SHIPS.—The s.s. Kangaroo (erroneously referred to as The Rangoon in the first Note printed in our last issue) arrived at Aden on Sunday last with the cable on board for the first section of the Cape line. The s.s. Seine is taking in cable to complete the connection between Mozambique and Natal, and will sail from London about 10 days hence. The s.s. Edinburgh will sail about the same time with a portion of the Australian duplicate cable on board.

MR. R. S. BROUGH.—We regret to say that Mr. R. S. Brough, late officiating electrical superintendent in the Indian Telegraph service, died suddenly on the 3rd April from cholera. Professor W. E. Ayrton, to whom we are indebted for this information, says of the late Mr. Brough that he was a man of considerable power, and notices many able Papers he had published. We have recently received several communications from the late Mr. Brough, and also a copy of Mr. Schwendler's book on testing, an edition of which had been edited by Mr. Brough in India and published last year.

EARLY ELECTRIC AND MAGNETIC MOTORS.—In 1833 Mr. Sturgeon exhibited a small magnetic motor. It was capable of pumping water, sawing wood, and drawing model carriages. It was but a small thing, but it showed the principle in operation clearly. In 1837, Dr. M. Connell of Pennsylvania made a small machine which caused a driving wheel to rotate seventy times a minute, carrying a load of 40lb. through a space of 300ft. per minute. The machine was 2ft. high and 1ft. broad, and weighed 17lb. A year or two afterwards Mr. Davenport of Vermont constructed several electro-magnetic machines, varying the method of construction. With a small machine he obtained a horizontal rotation 300 times a minute, and lifted a quarter of a hundredweight. In 1840 Mr. Clarke of Leicester constructed an electro-magnetic locomotive, which ran on a circular model railway, drawing from 60lb. to 100lb. According to the late Prof. P. Forbes, Mr. R. Davidson of Aberdeen constructed a galvanic machine, and actually worked a small lathe. This machine generated sufficient power to draw a small carriage containing two persons over a rough floor. In 1842, with Mr. Davidson's apparatus, a railway carriage was impelled at the rate of four miles an hour during an experiment on the Edinburgh and Glasgow line. In 1839 Prof. Jacobi navigated a small vessel on the Neva by means of electro-magnetism. The boat was 28ft. long, 7ft. 6in. wide, drawing nearly 3ft. of water, and carried fourteen persons. The rate of progress was three miles an hour. The Professor had tried an experiment in the previous year, but only obtained the result of about 1·5 miles an hour.

THE IMPERIAL COLLEGE OF ENGINEERING, TOKEI, JAPAN.—The instruction in telegraph engineering given at this institution consists of experimental and practical work in the physical laboratory and physical museum, together with a course of lectures of which the following is a syllabus:—1. Electricity and Magnetism, embracing all the parts of these subjects which have any bearing on telegraphy. 2. The construction of land and subterranean lines, embracing the manufacture, quality and method of testing the various materials; surveying and selection of route; erection of the line; strength of materials and structure, so far as necessary for telegraph lines; testing faults on the finished line; internal arrangement of a telegraph office; method of working a telegraph line. 3. The history and progress of telegraphy, including a description of the methods of signalling adopted at different stages, the kind of instruments used and the construction and theory of those instruments 4. Submarine telegraphy, embracing the preparation and properties of the materials used; the methods of testing these materials; manufacture of cables; relative quality and cost of different kinds of cables; shallow water and deep-sea cables; surveying the sea-bottom and selection of route; laying, testing and repairing cables; construction and theory of instruments used in the working of submarine cables. 5. Torpedo cables, method of laying, working, and precautions necessary in the working of such cables. 6. Besides the above, lectures are delivered on the mathematical theory of electricity and magnetism, taking up the easier portions of such books as Maxwell's "Electricity and Magnetism," Thomson's "Papers on Electrostatics and Magnetism," &c.

CANTOR LECTURES.—The third lecture of the course was given by Mr. W. H. Preece on Monday, May 5. The syllabus of this lecture states that the subjects to be treated were "Simple Telegraphy, Visual and Aural Signals, Telephones, Telegraphic writing." The syllabus was closely followed, except in the case of the telephone. The lecturer commenced by describing what he termed the simplest of all instruments, the Wheatstone's A B C, first introduced in 1840, but not practically till 1858. This was said to be a modification of Ronald's apparatus devised in 1816. The instrument is used in the Postal Telegraph Department to a large extent because of its simplicity, on March 21st, 1878, there being no less than 4,641 of these instruments employed. The five-needle

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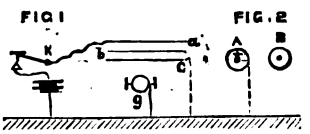
instrument of Cooke and Wheatstone was next referred to, and a historical *resumé* of the evolution of the ordinary needle apparatus given. The Post Office has 3,495 of these instruments at work. A description was given of the Morse system of dots and dashes, the Bell system, giving the equivalents of dots and dashes by sound, and the "sounder system" of Theiler, which was shown for the first time in England. A wire connected with the central office in Telegraph-street was brought into the room, and messages received by means of sound. It was stated that the mistakes made with sounders are fewer than with some of the other instruments. The use and construction of relays was explained. Sir C Bright's bell instrument was described, as was Hughes' type printer, of which the Post Office has four in use. *The Times* newspaper has the use of a private wire to Paris and Vienna, and uses the Hughes' apparatus for its messages. Ordinarily, however, a greater rapidity is required than can be obtained by the use of this instrument. Mention was made of D'Arlingcourt's apparatus, and Mr. Cowper's writing telegraph was shown in operation. The following collected statistics of the various apparatus in use by the Postal Telegraph Department at the present time throughout the United Kingdom are interesting:—Public and private instruments—Automatic, 167; printers, 1,560; bells, 277; sounders, 1,380; needles, 3,495; A B C, 4,641; other kinds, 859—giving a total of 12,379 instruments. The mirror system of working on long cables, as well as Thomson's recorder, was briefly mentioned.

A Magnetic Survey of the Fortieth Parallel in North America between the Atlantic Ocean and the Great Salt Lake, Utah.—The following is an abstract of a Paper on this subject presented to the Royal Society by Prof. Thorpe:—"This communication contains the results of a series of observations of the three magnetic elements—dip, intensity, and declination—made along the fortieth parallel in North America between the Atlantic Ocean and Salt Lake City. Magnetic observations have been made, with more or less assiduity, at different places in the eastern States for many years past; but of the immense tract of country lying between the Mississippi and the Pacific Ocean there is only a single determination, of one of the three elements, indicated on Sir Edward Sabine's maps, viz., a determination of declination at Salt Lake City. A series of observations was made some years since by United States' officers along the Mexican frontier, and a similar series was carried out by the English and American officers employed on the North American Boundary Commission. The present set of observations was made, therefore, along the district which lies midway between the line of observations already run along the northern and southern boundaries of the United States' territory. The instruments employed formed part of the admirable magnetic equipment belonging to Owens College, Manchester, and were kindly placed at the disposal of the author by the Council of the College. At the commencement and end of the survey, a complete series of observations was made at Kew, which was adopted as a base station; and a similar set was made at Washington in the magnetic observatory belonging to Mr. Charles A. Schott, of the United States' Coast Survey Department, with a view of obtaining an independent check on the indications of the instruments. The author learned from Mr. Schott that the Coast Survey Department is gradually accumulating data for a discussion of the magnetic history of the American continent. It has already published a map of declination for 1870, from which it is evident that much has been done in the determination of this particular element since the date of Sir E. Sabine's memoirs, more especially along the Pacific slope, and in the regions to the west and south-west of the Great Salt Lake. As yet, however, no observations have been published relating to any of the districts west of the Mississippi visited by the author."

Electrodynamic Induction and Secondary Electrostatic Induction between Telegraph Conductors in Proximity.—In a Paper on this subject by M. de Meaux, in *Annales Télegraphiques*, the results of a series of experiments made (a) upon two gutta-percha covered wires, the external surfaces of which were insulated from earth, and (b) upon two such wires encased in lead by means of which the external surfaces of gutta-percha were connected to earth, are summed up as follows, so far as regards the electrodynamic effect:—*In a closed circuit, the intensity of the current determined by the induction of a cylindrical conductor of indefinite length upon another of the same form is not affected by surrounding one or other of these conductors, or even both of them, with a concentric metallic envelope, in communication with earth throughout its length.* In an article upon telephony, by Dr. Werner Siemens, in the same number of the *Annales*, the difference in the effects produced by the two modes of induction above mentioned is very clearly set forth. The following experiment, suggested by him, shows that the effects of secondary electrostatic induction are completely obviated by the external metallic envelope; the arc of which, it appears, was patented in England by M. Foucault under date of 2nd July, 1869. Let *a*, *b* and *c* represent three sheets of metal foil, insulated from each other by plates of mica or thin layers of gutta-percha. When the plate *b* is disconnected



from earth, the galvanometer *g* is reflected when the key *k* is depressed, by reason of the induction upon *c* of the charge communicated to *a*; this effect being in no wise diminished by the presence of *b*. If, however, *b* is connected to earth, then no effect is produced upon the galvanometer by depressing *k*; the induction being then exerted exclusively upon *b*. The analogy of this arrangement to the case of two conductors, enclosed in an insulating material which is coated externally with a conducting material, is shown in Fig. 2. When the conducting tube of A is connected to earth, the induced *minus* charge corresponding to the *plus* charge of the wire becomes accumulated upon the inner surface of this tube; whilst the *plus* inducteous charge passes to earth. If, however, the conducting tubes of A and B were insulated from earth, they would both become polarised, and a *minus* charge would be induced in the central conductor of B; the *plus* inducteous charge flowing through this conductor to earth. In regard to electrodynamic induction, Dr. Werner Siemens arrives at the same conclusion as that stated above; a conclusion established by the following simple experiment. Two gutta-percha covered wires are wound together upon a bobbin, which is gradually immersed in water. The effects of electrostatic induction are then observed to diminish; ceasing altogether when the bobbin is completely immersed. But the currents due to electrodynamic induction, instead of being diminished by the effect of the conductive contact between the external surfaces of the insulating coverings, which is established by the water, become by this cause intensified.

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ELECTRICITY AS A SOURCE OF LIGHT.*

BY PROFESSOR REDWOOD.

(CONCLUDED FROM PAGE 276.)

And now we arrive at another era. In 1876 Paul Jablochkoff, a Russian officer, invented a new method of producing the electric light by means of what he called his candle. This invention has attracted a vast deal of attention and excited great interest. The Jablochkoff candle, as it is commonly called, has been more extensively used for public lighting than any other form of electrical apparatus; and I believe it was this principally that led to the construction of the very beautiful, compact, compendious, and yet powerful machines called dynamo-electrical machines that are now used for the production of current electricity. The candle has the great recommendation of extreme simplicity. It consists of two thin rods of carbon placed side by side, with an intervening layer of plaster of paris. The carbon rods are connected at the top by a little bridge of carbon, through which the electric current at starting passes. This, being very slight, becomes incandescent, and soon burns away when the electric arc is produced. The plaster of paris is dissipated in the flame, which, if the current be maintained without flagging, and the carbon poles do not alter their relative positions, will continue to pass across from one of the carbon rods to the other. The carbon terminals, however, would soon alter their relative positions if the current were always passing in one direction, because the positive pole would waste more quickly than the negative; but this difficulty is easily met by making the current an alternating one. With a galvanic battery of course the current always passes in one direction, and as I am using a battery I am unable effectively to keep up the light with this candle. In the magneto-electric machine the current of electricity, which is produced by the rotation of the armature in front of the poles of a magnet, is constantly reversing its direction, and this is precisely what is required for the Jablochkoff candle. It seemed to be the one thing wanting to make the candle capable of maintaining its action without further attention as long as the carbons will last, which is rather more than an hour.

The principal objection to the Jablochkoff candle is that if, from any cause, the light should become extinguished, there is no ready method by which the candle can be relighted. You must either go up to the lamp, take the globe off, and re-establish the current by means of a new bridge, or else you must turn the current to another candle (of which there are several in each lamp) by means of a switch provided for the purpose.

I understand that at the Holborn Viaduct they are sometimes left in darkness for several minutes (on one occasion for a quarter of an hour) while extinguished lamps are being relighted. There is an ingenious contrivance, represented on the diagram, by which, when a candle has burnt down to its socket, the current is automatically transferred to a neighbouring candle.

With the beautiful dynamo-electric machines which are now produced by Gramme, Siemens, Ladd, and others, there is no difficulty in getting any amount of either direct or alternating currents of electricity, and the only questions in connection with electric lighting that have to be solved, are first, the cost of thus producing the electricity; secondly, the best form of regulator for giving the light; and, thirdly, the extent to which a current can be broken up and made economically available for many lights.

We have no data as yet to enable us to solve the first of these questions, and I shall not this evening attempt to deal much with the last, but in connection with the Jablochkoff candle, I may remark that in the public displays that are made of it in different parts of London, the largest number of lights, as far as I have been able to ascertain, that are supplied from one cable wire, is five. I have no doubt that a larger number could be supplied, but I presume not economically. This is a question we shall have to go into more fully at our next meeting. I only allude to it here incidentally.

In the Jablochkoff candle all complicated mechanism is done away with; that is a strong point in its favour. But it is short-lived and has no recuperative power, which are its drawbacks.

The Wallace-Farmer and the Werdermann regulators are also free from any complicated mechanism, for the former has only a self-acting electro-magnet, and the latter a weight, by which the poles are kept in position. These regulators have not yet made their appearance before the general public, but they are candidates for public favour, and are dressing their plumes in preparation for an early display of their powers.

The Wallace-Farmer regulator consists of two carbon plates, each about half an inch thick, nine inches long, and three inches broad. They are placed one over the other in a grooved frame with two of the longer thin edges of the plates brought vertically into contact, or nearly so. The lower plate is fixed, while the upper one, which forms the positive pole, slides up and down vertically in the frame, being supported when in action by an electro-magnet, which keeps it at a short distance from the negative plate. The electric discharge takes place at the point at which the surfaces happen to come nearest together, and as these wear away the light travels along the contiguous edges of the plates to and fro as long as the carbons last. These regulators, I believe, are not so much intended for use in lamps as for rough open air use in cases where an enduring light is required.

The Werdermann regulator is the last I have to notice; but, although last, I by no means consider it the least promising of the several forms of apparatus we have before us. It appears to possess some very important advantages which adapt it not only for general use, but for some purposes where some regulators would be inapplicable.

Mr. Werdermann has kindly supplied me with some of his lamps, and he is here to correct me if I should give an imperfect description of them.

The first and most striking peculiarity in this regulator is the great disparity between the sizes of the two terminals or poles, the one being more than sixty times greater than the other. Then another peculiarity is in the relative position of the poles, the positive being below the negative pole, which is the reverse of what is usually the case. And then, again, unlike all the other regulators, the poles are kept constantly in contact, but the lower or positive pole being a rod of very small diameter, the points of contact are insufficient to carry the current, and they are, therefore, surrounded by the usual arc, although this is extremely short and scarcely perceptible.

Mr. Werdermann appears to have been led to the adoption of this arrangement as the result of a series of experiments in which he found that, starting with the two poles of equal size, and as usual with the positive above the negative pole, then gradually increasing the size of the positive pole while the negative remained unaltered, it became necessary, although the current remained the same, to shorten the distance between the poles until at last, when one pole was sixty-four times greater than the other, they were brought into contact, and were required to be kept so in order to produce the light. In effecting these changes, while the lower negative pole was successively increased in diameter it was observed that an accumulation of carbon took place on the negative pole immediately under the positive pole, and this continued until they came into contact.

The experiments were then carried in the opposite direction, the negative pole being kept of the usual small size and the upper positive pole being gradually increased until as in the other case it was sixty-four times greater than the other, when it was again found necessary to keep them in contact in order to produce the light. In these latter experiments, however, the larger pole, which was now the positive pole, had a depression or small pit formed on its surface instead of the elevation or pimple formed in the previous experiments.

The practical result in both cases was, that by increasing the size of one of the poles until it became sixty-four times greater than the other, a good and steady light was produced by keeping the poles in contact. It appears that the best effect is produced with this arrangement when the positive pole, in the form of a very slender rod is placed below the negative pole, the latter being about three inches in diameter.

* Substance of a lecture delivered before the Pharmaceutical Society of Great Britain, Wednesday, January 8, 1879.—(From the Journal of the Society.)

THE CONTACT THEORY OF VOLTAIC ACTION.*

By Professors W. E. Ayrton and John Perry.

The authors commence by referring to the experiments that had been made prior to 1876, on the difference of potentials of a solid in contact with a liquid, and of two liquids in contact with one another, and they point out that :—

1. The earlier experiments were not carried out with apparatus susceptible of giving accurate results.

2. Owing to the incompleteness of the apparatus, assumptions had to be made not justified by the experiments.

3. *No direct* experiments had been performed to determine the difference of potential of two liquids in contact, with the exception of a few by Kohlrausch, using a method which appeared to the authors quite inadmissible as regards accuracy of result.

In consequence of this, great vagueness existed as to whether the contact difference of potentials between two substances, when one or both were liquids, was a constant depending only on the

* Abstract of a Paper read before the Royal Society, March 13th, 1879.

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substances and the temperature, or whether it was a variable dependent upon what other substance was in contact with either. Some authorities regarded it as a variable. Gerland considered he had proved it to be a constant; but, first, the agreement of the value of the electromotive force of each of his cells with the algebraical sum of the separate differences of potential at the various surfaces of separation, which was the test of the accuracy of his theory, was so striking, and so much greater than that which polarisation, &c., usually allows one to obtain in experiments of such delicacy, that one could not help feeling doubtful regarding his conclusions; secondly, his apparatus did not allow of his experimenting with two liquids in contact, consequently he could not legitimately draw any conclusion in this latter case. And, although Kohlrausch had made some few experiments on the difference of potentials of liquids in contact, still, since he employed moist blotting paper surfaces instead of the surfaces of the liquids themselves, the authors considered for that reason alone, if for no other, that his results did not carry the conviction the distinguished position of the experimenter might have led them to anticipate.

They therefore designed a method, and an apparatus for carrying it out, by means of which they could measure the difference of potentials in volts at each separate contact of dissimilar substances in the ordinary galvanic cells, from which they could ascertain whether the algebraical sum of all the contact differences of potential was, or was not, equal to the electromotive force of the particular cell in question. From the results they obtained, and which are given in Papers Nos. I. and II., "Proc. Roy. Soc," No. 186, 1878, they concluded within the limits of their experiments that if $\overline{AB}$, $\overline{BC}$, $\overline{CD}$, &c., were the contact differences of potential, measured separately, of the substances *A* in contact with *B*, *B* in contact with *C*, &c., then, any one or more of the substances being solid or *liquid*, if any number *A*, *B*, *C* ..... *K* were joined together, and the electromotive force of the combination $\overline{AK}$, measured, the following equation was found true:—

$$\overline{AK} = \overline{AB} + \overline{BC} + \overline{CD} + \cdots\cdots + \overline{JK},$$

which proved that each surface of separation produced its effect independently of any other.

Their method by which any single contact difference of potentials was measured was as follows:—Let 3 and 4 be two insulated gilt brass plates connected with the electrodes of a delicate quadrant electrometer. Let 1 under 3, and 2 under 4 be the surfaces whose contact difference of potential is to be measured; 3 and 4 are first connected together and then insulated, but remain connected with their respective electrometer quadrants. Now 1 and 2 are made to change places with one another, 1 being now under 4 and 2 under 3, then the deflection of the electrometer needle will give a measure of the difference of potentials between 1 and 2; and in the present paper it is proved that in order that the observed difference of potentials in the electrometer quadrants shall be proportional to the contact difference of potentials desired to be measured, either there must be perfect symmetry in the induction apparatus before and after reversal of 1 and 2, a condition very difficult to be obtained, or else the plates 3 and 4 must, in addition to being connected together, be also put to earth, or reduced to zero potential, before each reversal, and also the mean potential of the substance under test must be kept as low as possible, conditions that were always carefully observed in the experiments.

The apparatus employed by the authors in the present investigation is then explained in detail, and it is shown how, by improving on their earlier form, they have removed a difficulty which formerly existed, and which prevented their previously experimenting on pairs of substances having very different weights, such as a vessel of mercury and a sheet of metal. The method of making the permanent and temporary adjustments, the tests for leakage, the experimental mode adopted of compensating the error arising from defects in parallelism of the apparatus affecting the results obtained from two rigid surfaces (as that of copper and zinc) differently from the result found with one or with two liquid surfaces under test are then described, as well as the details of a complete experiment and the precautions adopted to obtain clean metallic surfaces.

The authors explain that the results they have obtained in this investigation have divided themselves into three groups:—

1st. The contact difference of potentials of metals and liquids at the same temperature.

2nd. The contact difference of potentials of metals and liquids when one of the substances is of a different temperature from the other in contact with it, for example, mercury at 20° C. in contact with mercury at 40° C.

3rd. The contact difference of potentials of carbon and platinum with water, and with weak and with strong sulphuric acid. They, however, give only the results under head No. 1 in the present communication, reserving those they have obtained under heads Nos. 2 and 3 for a future occasion.

Then follow, arranged in the order in which they were obtained from January to May, 1878, some 150 results of experiments (each number being on the average the mean of eight observations), representing the contact differences of potential of nine solids and twenty-one liquids. They explain that the numbers given are those to which alone they attach importance; but that in consequence of much time having in such delicate experiments to be spent in obtaining measurements, which are often found out to be wrong, a considerable number of results have been rejected, and are not mentioned in the Paper, and that this, therefore, explains why in some cases one measurement only is apparently the result of a whole day's work. These remarks especially apply to the authors' attempts to measure the contact difference of potentials between a liquid and a paste, for example, mercury and mercurous sulphate paste, great difficulty being introduced by the extremely thin layer of water on the surface of the paste acting inductively instead of the paste itself. They mention that this difficulty is a very good example of the inaccuracies that must have been introduced by former experimenters using a moist blotting-paper surface instead of the surface of the liquid itself.

A large number of discordant results were obtained in March, 1878, and their explanation led to the interesting result that the apparent contact difference of potentials between a metal and mercury, as measured inductively, varied much with small additions of temperature. The accidental difference of temperature in the different experiments arose from the mercury having been redistilled in the laboratory between every two experiments to remove all possible traces of impurities, and probably in some cases it had not become perfectly cold before a new experiment was made. The investigation of this apparent change of contact difference of potentials with temperature led to a consideration of the contact difference of temperature of mercury with air, since, of course, in all these inductive experiments two air contacts are included in the result. The results thus obtained will form part of the substance of the next Paper.

Next follow a number of checks of the accuracy of the results based on the well known law that in any compound metallic circuit at uniform temperature there is no electromotive force. This is followed by some considerations regarding the measurement of the difference of potentials between substances and the air in contact with them, and of measurements of the Peltier effect.

It has usually been thought that the differences of potential of liquids in contact with one another were so small as to be almost inappreciable in comparison with the differences of potential of metals in contact; but the authors have ascertained, among other results, that strong sulphuric acid, in contact with distilled water, solutions of alum, copper sulphate, and zinc sulphate, has a measured difference of potentials of 1·3 to 1·7 volts, an electromotive force more than twice as high as that of zinc and copper in contact. And hence the importance of an apparatus that can directly measure the difference of potentials of two liquids.

ELECTRO-METALLURGY: HOW TO MAKE A BEGINNING.

(CONTINUED FROM PAGE 238.)

Electrotyping.—The sulphate of copper solution which has been mentioned is very useful for *electrotyping*; that is, obtaining a deposit of copper on a cathode which serves as a mould. One of the best materials that can be used for such a mould is *gutta percha* (pronounced *pertsha*). Suppose, for instance, you wish to copy a seal: you place a small piece of sheet gutta percha in hot water; and, whilst it is getting soft, you may slightly oil the seal, and also a piece of paper or wood on which, in order to prevent adhesion, the gutta percha is to be placed when removed from the water. All excess of oil should be removed from the seal; the gutta percha is then quickly removed from the water and placed on the oiled surface; any drops of water on the percha may be removed with blotting paper; and the seal is then pressed into the plastic material, the pressure being maintained until the latter has ceased to yield. When the percha has cooled, the seal is removed, and the impression is examined to see if it is perfect; if so, the excess of material may be cut away with scissors. A wire has now to be attached to the mould, and the surface has to be rendered conducting in order that it may act as an efficient cathode. Heat the extremity of a long fine wire, and quickly press it into the edge of the mould, so as not to injure in any way its surface. Then take some finely-powdered *plumbago* (some kinds of the common "blacklead" answer the purpose very well) and, with a camel-hair or other soft brush, coat with this material the whole of the

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surface which is to receive the deposit—taking especial care to bring the coating of plumbago *well up* to the wire which is to convey to it the current. The gutta percha may be breathed upon, or slightly warmed, in order to cause the plumbago to adhere; and the brush should be worked round and round until every portion of the impression is uniformly blackleaded. The other extremity of the wire may then be attached to the zinc pole of the battery, and the mould is made to constitute the cathode within the depositing cell by immersing it in the depositing solution opposite the anode or copper plate attached to the positive pole. When a deposit of sufficient thickness has been obtained, it should be gently detached from the surface of the mould; and it may then be trimmed with scissors, polished, and suitably mounted. Moulds, to be similarly coated with plumbago, may be made also of wax, or of plaster of paris; and we have seen some very good moulds made of sealing-wax—this material being very lightly brushed over with spirits of wine before applying the plumbago.

Copper Depositing Solution (*b*).—For depositing on iron (or on lead, zinc, tin, pewter, &c.): The sulphate of copper solution is not by itself of much use for *electro-plating*, properly speaking, that is, for depositing a permanent coating of metal, since we do not often require to coat copper, and still less silver or gold, with *copper*, whilst iron and the metals and alloy above mentioned decompose the sulphate solution. It is quite possible to deposit a coating of copper upon iron by means of this solution; but this coating will not be *adherent*. To deposit the first coating of copper upon iron, we require an *alkaline* solution (that it is to say, a solution that will neutralise an acid); and the best known and most frequently used solution of this character is the cyanide of copper dissolved in cyanide of potassium. But the latter salt is a very deadly poison; and, although safe enough in the hands of the skilled and careful chemist, it is, we think, too dangerous to be meddled with by beginners. We have, therefore, instituted a series of experiments with the view of finding an effective non-poisonous substitute for this salt. This has not been a very easy matter; for the deposition upon iron of a bright and perfectly adherent coating of copper is a problem which, though very perfectly solved by the use of a cyanide, has justly been considered a somewhat arduous task in electro-metallurgy, and one not admitting of a great diversity of processes. The solution for which the following is the recipe has given excellent results; and, although certain precautions would be needed for its successful employment on a large scale, it is one which, we think, will give perfect satisfaction to the beginner.

Recipe.—Solution for electro-coppering iron, &c. Weigh out:—Sulphate of copper, one dram; tartaric acid two drams; caustic potash (in sticks), two drams.

Dissolve the sulphate of copper in about half a tumbler-full of water. Also dissolve a small quantity of washing soda (about two drams) in warm water; and add the soda solution to the copper solution. Just enough should be added to throw down all the copper in the form of a green precipitate (basic carbonate of copper). This precipitate has now to be separated from the fluid (which is a solution of sulphate of soda). The quickest way to effect the separation is by filtration, in which a piece of blotting-paper, folded in four, and adjusted within a funnel, may replace the usual filter paper. Or, if time be no object, the precipitate may be allowed to subside, and the clear solution afterwards poured off. In either case, the precipitate should be washed with clear water, in order to remove the last portions of the soda solution.

Now dissolve the tartaric acid in a small quantity of warm water; get the moist copper precipitate into a tumbler, and pour the tartaric acid solution upon it. Effervescence will take place, or, in schoolboy parlance, the mixture will "fizz." Wait until all the gas (carbonic acid) has been evolved; then put the sticks of caustic potash into the tumbler; and add sufficient water to make up at least half a tumbler-full (1 gill) of solution. The potash dissolves the copper precipitate; the fluid becoming of a beautiful blue colour, without any sediment.

This solution may be worked by a battery of two of the zinc-copper-vinegar cells, connected zinc to copper, or by one of the magnesium-copper couples with solution of salt as the "exciting fluid."

It is possible that some difficulty might be experienced in obtaining the caustic potash; and for this and other reasons it is desirable that the student should be able to manufacture a solution of this reagent from carbonate of potash (or pearlash) and slaked lime. Instead of the two drams of caustic potash he may take two-and-a-half drams of pearlash, which should be dissolved in *less* than a gill of water—since it is to be remembered that the *total* volume of the solution is to be about one gill. He must also obtain a fragment of well-burnt lime, about the size of a hazel nut (this can always be got where there is any building going on, or it can be produced by burning a piece of chalk or an oyster-shell in a hot kitchen fire for a whole day at least). A few drops of water are to be sprinkled on to the lime, when, if it be well calcined, it will become hot and fall to a powder, in which condition it is said to be slaked. The lime is added to the solution of pearlash, well stirred up in it, and ultimately allowed to subside. A drop of the clear solution should then not effervesce when a drop of vinegar is added to it; the absence of any effervescence indicating that the whole of the carbonic acid has been removed by the lime, and that the carbonate of potash has thus become potassic hydrate or caustic potash. The solution thus made is to be used instead of the caustic potash in sticks; but in this case care must be taken to use no more water than will make up altogether about one gill of solution.

N.B. If ounces be taken instead of drams, a quart of solution will be obtained instead of a gill.

Any small piece of bright iron may be used as a cathode. To save time and battery-power, it is advisable to give to the iron only a thin coating in this solution; and to increase the thickness to any required extent in the sulphate of copper bath.

TELEPHONE *VERSUS* TELEGRAPH.

[Mr. Blount Thomas has forwarded a letter, written by Mr. H. R. Forster, which he thinks bears somewhat on Mr. Preece's remarks, made at the Society of Telegraph Engineers, on the occasion of the reading of Mr. Scott's Paper. The following paragraphs are those bearing upon the subject.—Ed. *E.*]

"... For several years past I have been engaged in forwarding by telegraph to Lloyd's, the Liverpool Underwriters' Association, the *Shipping Gazette*, and private ship owners, reports of all vessels showing their distinguishing flags off my signal station here; the total yearly number of these telegraphic reports is about three thousand. Finding the distance of this place from the nearest telegraph office (a full mile) a very serious inconvenience, I long since desired to establish direct telegraphic communication. Various difficulties, however, presented themselves, and I took no very decided action in the matter until I read an advertisement in your columns last October, to the effect that Mr. J. Blount Thomas, Professor Bell's agent at Southampton, was prepared to enter into contracts for establishing telephonic communication between places in the neighbourhood. The result of my negotiations with that gentleman was that, on the 14th November last, I first communicated by direct word of mouth between my house at St. Catherine's Point and the Post Office at Niton. My venture has certainly succeeded beyond my expectations. Not the slightest hitch has occurred from the first, and though I have a maintenance and repairing clause in my agreement with the contractor, I am glad to say that he did his work so well in the first instance, that in spite of a most trying winter, I have not as yet had any occasion to avail myself of it. I have been fortunate in securing the services of a very intelligent and competent assistant, who takes down telegrams from my dictation with perfect accuracy, and without the least difficulty. I may mention that these messages often contain from two to three hundred words, and among them are the names of many foreign ships, and other words of difficult pronunciation. The fact that these are almost always transmitted quite accurately speaks volumes for the articulating powers of Bell's telephone. .... Attention is called by pushing a button on the top of my desk, which instantly rings the bell at the other end of the line. The whole apparatus, bell, desk, and telephones occupy a space not exceeding two square feet. .... In the telephone no special instruction whatever is required. The simple 'necessaria' to successful working are fairly distinct pronunciation in the speaker and ordinary powers of hearing in the listener. Loud speaking is detrimental rather than otherwise, and a distinctly pronounced whisper, however low, is perfectly audible. I cannot but believe that as the telephone becomes better known it will be better appreciated, and that it will largely supersede the telegraph for many purposes. ..."

A "Waiting Battery" for Surgical Use, &c.—Amongst the applications of the electric light exhibited at the Albert Hall on Wednesday last, was the apparatus of M. Trouvé for illuminating cavities, such as those of the mouth and throat; which was shown by Mr. Coffin, together with the various cauteries known as "galvano-caustic." This apparatus is usually worked by the secondary battery of M. Planté; but on the occasion in question it was, for the first time, worked by a Zinc-Platinum battery, devised by Messrs. Coxeter and Son, on the principle of the Leclanché cell.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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SCIENTIFIC DISCUSSION.

There are two opposite views concerning the use of speech. The one oftenest quoted is, that speech was given to conceal our thoughts; the other—never avowed, but more often acted upon—is, that speech is to persuade people that our thoughts, whether we have any or not, are worth revealing. How much of the speechifying nowadays is indulged in solely with this latter aim the daily papers bear witness to; and how few are the thoughts discoverable therein every intelligent reader can testify. The people who think are, admittedly, a small minority; not very many ever even desire to think; but almost everybody wants to speak, and the number who try to do so increases at a rate that is truly appalling. If you start a conversation about the weather, the "well read" young man of the period replies with studied phrases—struggling in the throes of incipient speech-making. And the misfortune is, that the man who could say something worth listening to keeps silence because he has no mind for "talking like a book" like his neighbours. It was observed long ago that the art of conversation was lost to us. The trick of speech-making has taken its place. Parliamentary Debating, which is responsible for this state of things, had once a real persuasive power. It ceased to have that so soon as it was consciously addressed to the constituencies. But the superstition remains that it has something to do with our liberties, and in any case that it is dignified. The Town Council of course imitates it; it illuminates the Vestry; it descends to Working Men's Clubs, and every Railway Compartment is a discussion forum where set speeches are let off. This being the case, it is not surprising that Learned Societies should catch some of the infection. Science claims to be almost superhuman in its aims; but its votaries are only mortal, and those of them who have the gift of speech can hardly be expected to keep it under a bushel when the demand for it is so urgent, and the reward so glittering. Scientific speechifying is consequently in the ascendant; it has its copyists, like the kinds just referred to; and perhaps the most unendurable of all human bores is the learned prig who buttonholes you in the ante-room. Let us look, not illnaturedly, at some of the inconveniencies which naturally arise out of this, comparatively, new and strange habit.

Dismissing from our present consideration the two or three Institutions which are either the mere receptacles, or the publishers, of scientific work—where research and discovery are permitted to receive honourable record, or where only the higher functions of the teacher are exercised—we come to those Societies the great majority of which have been promoted for the investigation of special and distinct branches of science, in some instances for their relation to particular professions, but in many others for the sake of the science alone. There is no risk of being invidious because so far as our experience goes few if any can claim exemption from the inconvenience to which we are referring. A paper is read. It has previously undergone the ordeal of an examination by the leading men of the Society, whose attendance at the reading will consequently depend very much upon the estimate they have formed of its value. The rank and file of the members listen with painstaking effort to understand, and a praiseworthy appearance of being edified. If the subject is new, abstruse, or startling, there is obviously nothing to be done until the paper is printed; the Chairman therefore rises, and, with the becoming air of a man whose breath has been taken away by the "revelations we have heard this evening," and "if no one has anything to say," he postpones the discussion till another evening. But of course he makes a speech of it. It is often a good one, and the only redeeming feature of the gathering. Its transparent artificiality however is, we cannot help thinking, an evil. Unless there is present someone who can and will make a speech about anything, from the differential calculus to the newest form of drain pipe, nobody has the temerity even to ask a question. If the subject is familiar and capable of being discussed there and then, the conditions are more favourable, but the result is, if anything, still more aggravating. Ex-

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haustive indeed must be the paper that has not some flaw in it; the powers of elucidation must be great indeed in him who can explain his apparatus, his diagrams, or his formulæ without leaving something to be desired. Yet what usually happens? A dead silence. Some societies have a special providence in the shape of a speaker such as we have just described. He is always ready to throw himself into the breach; the pity is that so few are willing to follow. Most societies however are not so blessed; and in any case, speech or no speech, it is known that speech-making is the order of the day, and that it would betray a littleness of mind unworthy the occasion to get on one's feet to make a simple inquiry. Twenty people would like to put questions, a few would like to make suggestions, and perhaps every member present has one question at the tip of his tongue—a question so obvious that the paper has omitted to anticipate it—which remains eternally unanswered because nobody has the courage to break through established usage. If one or two persons do contrive to force a hearing, they seldom represent the wants of the meeting—for speech making has a weak as well as a strong side; and if the shamefaced and disappointed audience do not feel quite sure that their silence has proved golden, they have a grim satisfaction in knowing that the speaking has often been leaden, or brazen, and *not* silvern. The upshot of it all is that the Paper is not discussed, in any real sense, at all; and, what is worse, very little fresh information is brought to light.

It must not be supposed however that we are disparaging the art of speechmaking; on the contrary it is as gratifying as it is, perhaps, surprising that so many eminent scientific men have cultivated it so as to be able to deliver a good speech, or better still, to say the right thing in a right way at the right time. All that we would suggest is the turning of this talent to the encouragement and not to the discomfiture of their auditors. There is a time for everything—even for unmitigated speechifying. On stately occasions it is not only endurable, but enjoyable. When however real business has to be done, an oration is like gilt on a poker—while you are admiring it the fire goes out. The British Constitution would be a sickly thing indeed if Cabinets and Private Committees were addicted to oratory. Now there are occasions, not unfrequent, when to get a scientific subject thoroughly threshed out, would confer a valuable and lasting benefit. We study the proceedings of Scientific Societies in vain for such a result. Yet we cannot help thinking that any well considered, and sincerely directed effort to bring it about would be attended with a quite commensurate success. Most men are ready enough to talk about their achievements in private; excess of modesty is not a prevailing weakness; the wonder is that mere usage or the tone of a public gathering restrains them into silence. A key is wanted to unlock their tongues, and we believe it could be found, first in more cordial invitations; secondly in freeing the atmosphere from formality; and lastly in the cultivation of a general understanding that they have met to tell each other all they know. We are not unmindful of the fact that there are people who habitually attend for what they can catch, learning all they may, and imparting nothing. Theirs is the reticence of the huckster, and if they opened their mouths it would be to complain that the Patent Office does not keep open till eleven p.m. We mention them only to pass them over; if anything could put them to shame it would be frank and unrestrained discussion of the kind we are advocating.

Our remarks, so far, have had a general application; but it is evident that they are especially appropriate to Societies devoted to Sciences which are experimental. Not long ago we advocated the formation of an Electrical Society, and we have reason to know that the need for such a society is very widely felt. In some respects this present Article indicates more specifically what is wanted, as well as the hindrances—some of them unavoidable and even unobjectionable in existing Societies—that tell against the proper discussion and advancement of Electrical research. We do not say that a quite satisfactory affiliation with, or enlargement of, some established Society might not be effected. But we do say that, to be a reality, its gatherings must be freer, less formal, less pretentious, and more genial than those of any Society we know of. There is, we are persuaded, a quantity of Electrical information, the result of past and present experiments, which requires to be gathered in and discussed. At present there is no opening for it, and no encouragement for the study to be pursued with distinction. Its character is, and must necessarily always be, very miscellaneous, sometimes trivial, often emanating from amateurs, but generally worthy of record and of being discussed. We say discussed; but in reality what we desiderate is a general interchange of ideas and experiences. Opportunities for such would be a distinct gain to almost every learned Society; to an Electrical Society they are indispensable.

AN ELECTRICAL SOCIETY.

The following letter, by a veteran electrician and telegraph engineer, is, in our opinion, of the utmost prospective importance in relation to the outward organisation by means of which the progress of electrical science may become manifested:—

TO THE PRESIDENT AND COUNCIL OF THE SOCIETY OF TELEGRAPH ENGINEERS.

GENTLEMEN: At the time of the formation of our society, and on subsequent occasions, I have endeavoured to point out the danger and disadvantages that would arise if our society, following too closely in the steps of our parent institution, were to assume too professional and technical a character, and to fail to attract the support of that large and increasing body of electricians who have no connection with telegraphic engineering or the practical applications of electricity, but who pursue the subject from a pure love of science. Among such are many workers of the highest acquirements who are not among our members, and who are not naturally attracted to a society bearing so distinctively professional a title as ours. In view of the daily increasing importance of electricity, the interest it is exciting in the public mind, and rapid spread of physical education, it appears to me quite possible that the class of whom I am speaking may, before long, become sufficiently numerous and powerful to support an independent society, unless we ourselves occupy the ground thus left vacant. But such a duplication of means is unnecessary, and would not be conducive to the progress of our own society. We have the necessary organisation, and it appears to me that a very slight alteration in our procedure and in the name of our society would enable us to attract to our ranks a large number of amateur electricians and men of science, who have not hitherto joined us because they do not feel desirous or qualified to enrol themselves as members of a professional society, and who are by no means assured that electrical researches of a purely scientific character would be appreciated by us.

It behoves us, therefore, to consider whether we ought not to endeavour to meet this want by somewhat enlarging the scope of our society. The best way of effecting this can only be determined by due discussion, but, in order to give a definite character to my proposals, I would suggest as a starting point for discussion that it might be advantageous that our society should assume a dual name and character, and become "The Electrical Society and Society of Telegraph Engineers." That the meetings should be held more frequently, and that certain evenings should be devoted to electrical matters of a purely scientific nature; the other evenings being devoted to technical papers as at present. All members would of course have the same privileges, but it is probable that those habitually attending the purely scientific meetings would gradually form a distinct class, and, in time, members of council would be chosen

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from this class, and the scientific evenings would assume a character of their own.

Our rules are founded on those of the Institution of Civil Engineers, and it therefore follows that membership of our society is supposed to confer or imply a certain professional status, which ought not to be attainable by members, however learned and eminent, who do not possess the requisite qualifications. This and similar difficulties would require careful consideration; but it would, I think, be a reproach to us if we were to continue to permit our organisation to remain too narrow to embrace the whole field of electrical science, or to allow any class of workers to feel themselves excluded from co-operation with us by reason of our too technical character.

I gave full expression to these views in my inaugural address in 1875, and I have long contemplated pressing the subject again upon the attention of the society. An article which appears in *The Electrician* of this date, advocating the formation of an independent electrical society, shows that others are entertaining the same ideas, and leads me to make this communication to the society.—Yours, &c.,

LATIMER CLARK.

Westminster, March 22nd, 1879.

CORRESPONDENCE.

ELECTROSTATIC POTENTIAL.—THE NATURE OF ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to Mr. Sprague's last communication under the first of these headings, I have to point out to him that electromotive "force," or difference of potential, cannot possibly mean "square root of energy;" since electrical energy varies, *cæteris paribus*, as $\frac{E^2}{R}$, and, according to his assumption, we should thus have $E = \frac{E}{\sqrt{R}}$.

The view that electricity can, in any sense, be regarded as being "simply energy" is, in my opinion, equally untenable. I am aware that it is held, in a vague way and on *à priori* grounds, by a goodly number of electricians, who nevertheless have never even attempted to make out a *primâ facie* case in its favour. On the other hand, it has repeatedly been disproved, both mathematically and experimentally, by rigidly scientific and logical methods. Its continued prevalence can be clearly traced to what Mr. Herbert Spencer would term an "atmosphere of bias;" and the best proof of this is that no endeavour has been made—nor, in my opinion, will be made—to give it some kind of *locus standi* by attacking the adverse demonstrations. Indeed it frequently happens that those who hold the view in question inadvertently disprove it themselves. Mr. Sprague furnishes a case in point; for, according to him,

$$\text{Electricity} = W = \frac{E^2}{R}\theta = E\,I\,\theta = I^2\,R\,\theta.$$

But, again, according to his view,

$$\sqrt{W} = E, \text{ or } W = E^2.$$

Whence, by Euclid's first axiom, we should have

$$\text{Electricity} = E^2 = \frac{E^2}{R}\theta, \text{ \&c.}$$

Mr. Sprague says that he "sees nothing terrible in the consequence" that his view would "require potential to be electricity." Yet, a little further on, he gives us his view that potential means $\sqrt{\text{energy}}$, and that electricity is "simply energy." I must confess that all this seems somewhat "terrible" in the case of an electrician who has obtained the undoubted proficiency of Mr. Sprague in many branches of electrical science; since it indicates the lamentable condition of electrical theory in the present day. Mr. Sprague, however, is just the man to revise most effectively his own theory, and that of many others, if the necessity for so doing should be rendered evident to him.—Yours, &c.,

DESMOND G. FITZGERALD.

THE ENERGY STORED UP IN AN ELECTROSTATIC CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am not quite sure that Mr. Desmond FitzGerald's letter, on page 283 of your last issue, calls for a serious answer, because I doubt very much whether he believes the dogma he is apparently endeavouring to support, and whether he feels satisfied with his own reasoning thereon.

One cannot but admire the ingenuity with which he clings to, and tries to prop up, a rash statement, made under a misapprehension and founded upon nothing at all, in the vain hope that it may turn out to be true; but although statements so made and so founded do occasionally turn out to be correct, yet the probabilities are so heavily against them that I am surprised that Mr. FitzGerald should have thought it worth while to cling to his dogma with such a feeble hope.

He argues now that a point in a polarised dielectric *must* have a charge because a wire tipped with flame will convey electricity away from such a point to the earth. I suppose he has seen the fallacy of such a mode of reasoning before this. As well might you say that when you apply your knuckle to a point on a charged conductor and receive a spark, all the electricity which "runs to earth" previously existed at the point you touch. Evidently the quantity which would run to earth would have nothing to do with the charge of the point touched, but would depend on the capacity and potential of the whole conductor (being equal to the product of these two things); and it might be varied at pleasure by increasing the capacity, without altering the potential in the slightest degree.

And surely Mr. FitzGerald must know perfectly well, first of all that a *point cannot* be charged, and, secondly, that a surface in a polarised dielectric *is not* charged, except under certain exceptional circumstances, *e.g.*, when the dielectric is heterogeneous, or when partial disruptive discharge has taken place.

The electricity which would run along his wire from the point would be really obtained from the surface of conductors in the neighbourhood, whose charge would accordingly diminish; and it is perfectly true that the loss of energy of the system (or the work done by the current in the wire) is $\frac{1}{2}QV$, where V is the fall of potential of the point in question, and Q the quantity transmitted by the wire.

This fact follows at once from the ordinary definition of potential,* but it has nothing on earth to do with Mr. FitzGerald's statement, which at the end of his letter he repeats as if deduced from it, that the quantity Q previously existed at the point in question.

Mr. FitzGerald wishes the expression $V = \frac{2W}{Q}$ to be admitted as a definition of potential; and this, if he thinks it simpler, and likes it better than the ordinary definition, is perfectly legitimate, provided it is understood properly and stated correctly: but it is precisely the same thing in other words, and of course follows from it.

And as to recognising his old friend *Tension* in this definition, it depends entirely on what he has meant by "tension." The great objection to this word is that it has been used in such a vague way, to mean anything and almost everything; but it is possible that a man of Mr. FitzGerald's experience has, like Mr. Latimer Clark in his useful little book, used the word with a fixed meaning, viz., the meaning which other people (in a rather better defined manner) attach to the word *potential*. And if this be so, then of course there is nothing extraordinary in his recognising in any correct definition of potential a good many features of his old friend.

If I may appeal to Mr. FitzGerald as a representative of what I suppose he would call the *non-scholastic* school of electricians, I would respectfully ask him to think it possible he is mistaken in his repeated assertions that the word tension has no real and useful meaning apart from potential. The latter word *has* become established, and I imagine that Mr. FitzGerald, and those who agree with him, know very well in a practical way what the thing is which is so called. Would it not now be wise for him therefore, instead of tilting against words, to find out what the meaning really is, which say Professor Clerk Maxwell, or any other authority, attaches to the other word, tension; and then to decide for himself whether this is, or is not, a perfectly distinct thing from that which he has so long called by that name. And if he does this and finds it to *be* different, as I assure him he will, then whether he calls the two things *potential* and *tension*, or V and T, or *A tension* and *B tension*, or what he likes, he will at any rate not waste his time by asserting over and over again that there is only one thing to be named, and that when people say *potential* they mean either tension or nothing, and that when they say *tension* they mean the same as he means by it.

I am emboldened to appeal to him in this manner by the magnanimity which he has shown in his recantation (cautious and tentative as in wisdom it is) of his old opinion concerning the capacity of bodies in space, as soon as the erroneousness of that opinion was made clear to him; and one is led to hope that such

* Thus:—The potential of the point falls during the discharge uniformly from V to 0, therefore its average value is $\frac{1}{2}$ V; and therefore (by definition of potential) $\frac{1}{2}$ V units of work are on the average done for every unit of electricity driven from the point to earth. But Q such units are so driven, therefore the total work done is $\frac{1}{2}$ Q V.

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a "leader of the opposition" as himself may in time come to acknowledge that the mode of regarding electrical facts inaugurated by Faraday, and carried on and greatly extended by Maxwell, is not only by no means so divorced from fact as he now imagines it to be, but is decidedly more simple, and incomparably more powerful, than the vague definitions and mystifying modes of reasoning which the "non-scholastic" school of electricians have invented for themselves.—Yours, &c.,

OLIVER J. LODGE.

CAPACITY OF A SPHERE IN SPACE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. FitzGerald asks for a little new light on the above subject from mathematical contributors, but it is really so simple a matter that I doubt whether any mathematicians will think it worth while to reply to the request. If they do, however, this letter will be unnecessary.

All I wish now to say is that if Mr. FitzGerald will hang a sphere up in a moderately large room, and will measure its capacity in absolute electrostatic measure, he will find it only a fraction greater than its radius; the difference in fact will be within the limits of probable error.

Thus, suppose the room is twenty feet across, and that the sphere hung in its centre is six inches in diameter, then the capacity of this sphere will be about 3·08 inches, which is very near its radius. If the room were bigger it would be still nearer, and in an infinitely big room it would be exactly its radius. Mr. FitzGerald need therefore have no difficulty or hesitation in completing his acceptation of the orthodox teaching on this point; because it is certainly, and one may say *experimentally*, true.—Yours, &c., OLIVER J. LODGE.

CHARGE AND INFINITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It was with some regret that I read the letter of Mr. Sprague on page 285 of your last issue under the above heading. The first dozen lines are a perfectly fair and well-deserved rap over the knuckles for my absurd interpolation of a sentence in parentheses containing the word "orthodox:" I willingly admit that I ought to have left it as I had originally written it, "the conclusion is *not true*, therefore," &c. But the rest of the letter is more worthy of some paradoxist or circle-squarer than of a physicist of Mr. Sprague's ability and experience. Discussion is impossible with a gentleman who, after blaming me for attempting to define infinity (which I never did), proceeds to define it himself by an extraordinary reference to the Deity.—Yours. &c., OLIVER J. LODGE.

MOMENTARY CURRENTS IN WIRES.

BY F. C. WEBB, M.I.C.E.

(CONTINUED FROM PAGE 286.)

In the case of the effect between wires situated near one another, we may first suppose a wire surrounded by a cylinder of metal, which cylinder is insulated from the earth except at it its two ends. Then the inductive action will go on entirely between the wire and the cylinder, and an equal charge of opposite electricity to the charge on the wire will be brought on to the inner surface of the cylinder. Thus, if A B be the wire, and A C B represent the positive charge on it, then if F P represent a small portion of the cylinder throughout its whole length, the negative charge will be represented by F G P, where F G is smaller than A C, shewing a smaller density in the charge at F than on the wire, in the inverse proportion of the diameter of the cylinder to that of the wire. Now, we may consider a wire as a portion of such a cylinder, and this will, therefore, represent the case of a wire situated near another. To satisfy the negative charge F P G, a rush of negative electricity will enter at F from the negative pole through earth and E F, causing a current at F exactly opposite to that entering A. But whether some will also enter from earth at E to P seems doubtful, and is a very interesting point to determine. If any does enter at P, it can only be during the period between the current at B first appearing, and the moment when the current at B attains its maximum and permanent state; for, if it occurred before this, we should actually have signals appearing at the end of the secondary wire before they appeared in the primary, which would seem an absurdity. When the wire A B is allowed to discharge by placing A to earth, then charge in F P will also flow out at F, causing a current the reverse to the discharge from A, or, in fact, in the same direction as the primary current in A B. Some of the charge in F P will also flow out at P, causing a current reverse to the primary flowing from B.

Thus, Fig. 2 would represent the relative currents produced by the electrostatic charging on making contact, and Fig. 3 those on breaking contact and putting to earth.

Now, the effect of electro-magnetic induction will cause a current in the reverse direction to the primary throughout the entire length of the secondary wire as in Fig. 4, and the cessation of the primary current will produce a current in the same direction as the primary throughout the secondary wire as in Fig. 5, where the primary is represented as having no electrostatic discharge. Now, it will be seen that as regards the end near the sending or battery end of the wires, the currents produced by the electrostatic effect, and produced by the electro-magnetic effect, in the secondary wire, are in the same direction both on making and breaking contact, but as regards the distant or receiving end, on making contact it is doubtful whether the current produced by the electrostatic effect is *nil* or *against* that produced by the electro-magnetic effect, but it certainly does not add its effect to that of the electro-magnetic action. On breaking contact it is clear, however, that the currents produced by the electrostatic and electro-magnetic action at the distant end are in opposition, as shown by comparing Fig. 3 with Fig. 5. At the near or battery end, therefore, we have no means of distinguishing the effect of electrostatic from that of electro-magnetic induction; but at the distant end we have, as the currents produced are opposite during the break of contact.

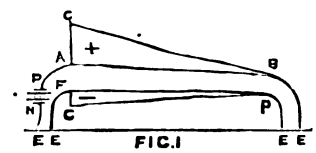

FIG. 1

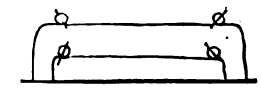
FIG. 3

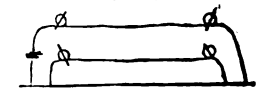
FIG. 4

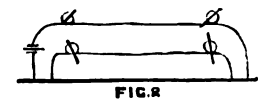
FIG. 2

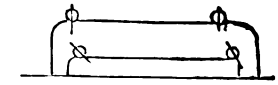
FIG. 5

In experimenting on the effects of induction on neighbouring wires, it must in some cases be difficult to say whether the effect is due to electro-magnetic or electrostatic action, and it is only at the distant or receiving end where this can be distinguished by the direction of the current. The strength of the currents may, perhaps, afford a guide if elaborate calculations are made to determine what ought to be the effect of electro-magnetic and electrostatic induction in each case. But, without such calculations, some information could be obtained by experiments on charging and discharging with the distant ends insulated, and comparing the effect with that when the ends are to earth. For, as regards the static charge in a wire, if the battery resistance is very small, the charge with end insulated should be double that with end to earth, and the discharge will be the whole of this charge. When the end is to earth the discharge at the near end is two-thirds of the total charge, or one-sixth of the discharge if the end is insulated. The same should hold good for the charge and discharge in the secondary. That is, if we measured the discharge from secondary when the primary has been charged with the ends of both wires insulated, and then measure it when the two wires are to earth, we should get one sixth the effect in the second case if the effect is due entirely to electrostatic induction, and, if more than this is produced, it must be due to electro-magnetic induction.

If wires are entirely surrounded by a perfect earth, it is evident that they can have no electrostatic effect on neighbouring wires, and that any effect produced between wires so separated must be due to electro-magnetic induction. But there are not many cases where wires so near to one another as to permit of electro-magnetic induction are so separated by a perfect earth. Suspended land wires have evidently no separation by a conductor, underground wires may be in many places dry on their exterior. Compound submarine cables are the nearest approach, as no doubt water forms a very close attempt to entirely surround each wire, but the pressure of the wires against one another in the manufacture may still keep portions of the gutta percha squeezed together so as to exclude the water for that portion of the circumference the most important to separate, viz., the portion exactly situated between the two wires. Altogether the subject of how far the interference on wires from currents is due to electro-magnetic or electrostatic induction is one that requires some careful consideration and experiment.

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THE ELECTRIC LIGHT AT THE ALBERT HALL.

On Wednesday, May 7, Mr. W. H. Preece, Electrician to the Postal Telegraph Department, delivered an inaugural address on the occasion of the opening at the Albert Hall of an Exhibition of Electric Light Apparatus. In this large Hall was assembled a numerous and appreciative audience, among whom were the Prince of Wales, the Duke of Edinburgh, Prince Christian, and the Duke of Teck. The Duke of Edinburgh, as senior Vice-President of the Albert Hall, introduced the lecturer, who said:—

Your Royal Highness, my Lords, Ladies and Gentlemen: The most brilliant luminary we possess on this earth is the sun; the worst is the farthing dip or rushlight. Between these we have various modes of artificial illumination dependent on the consumption of tallow, wax, oil and gas, and on electricity. All these systems owe their luminosity to the same cause—*heat*. The hotter the body the greater the light. Hence the production of brilliant light simply depends upon the production of intense heat, and the best light is that which concentrates the greatest amount of heat on the smallest quantity of matter. [These points were illustrated by experiment.] Heat can be produced by various chemical, physical, and mechanical processes. But the greatest concentration of heat can be produced by electric currents in overcoming resistance. When the resistance is the air itself, the *electric arc* is the result; when it is a metal or a carbon rod we have light by incandescence. Hence in the production of the electric light the principal question that we have to solve is the production of currents. This was solved by Faraday in the year 1831, who showed how it was possible by the mere motion of a wire in the field of an electro-magnet to convert the muscular energy of the arm into the energy of electric currents, and thus to produce heat and light. Light as the result of electric currents is no child. It was born in the same decade as gas and the steam engine, but while the latter have grown into immense giants the former remains a mere stripling. Its growth has been very slow, and its stages of growth are marked by different epochs. Davy in 1808 discovered the arc; Faraday in 1831 showed how to produce currents from mechanical energy; Foucault in 1848 showed how to produce the electric lamp; Nollet in 1850 showed how to apply steam to Faraday's engine; Holmes in 1857 showed how to apply this engine to the production of light, and showed how lighthouses could be illumined by electricity; Siemens in 1854 made a further step in progress by diminishing the obstructions to the production of electricity; and Wilde, Varley, Wheatstone, and Siemens in 1866 showed how currents can so react on each other as to obtain a maximum effect. The various machines based on the principles discovered by Faraday, Siemens, and Wilde are all exhibited in this building, and they are all dependent upon the rotation of coils of wire in a powerful magnetic field. When this field is produced by permanent steel magnets we have what are called magneto-electric machines, illustrated by Faraday's original machine, by Saxton's, by Clarke's, by Holmes's, and the latest form of this machine—De Meritens'. When this field is produced by the current itself we have what are called dynamo-electric machines—illustrated by Siemens', Gramme's, Wallace-Farmer's, and several others. Now the various lamps that are employed to utilise the energy of the currents formed by the above machines may either take the form of the arc which is practically illustrated by regulators based on Foucault's original form designed by Serrin, Siemens, Rapieff, Lontin, Wallace; and many others which are illustrated on the counters.

The form of light dependent upon incandescence either of carbon or of wire is illustrated by the lamps of Werdermann and the Anglo-American Light Company, and there is a third form of light called the "electric candle," which partakes of both the arc and incandescence, and which, from its wasting away like a wax taper, is called a candle, and is illustrated by that of Wilde and that of Jablochkoff, which is so well known as employed in the illumination of the Thames Embankment. [All these lights were shown in action.]

The electric arc is a little sun, and its light is if anything purer than that of the sun. The light from incandescence is not so pure nor so intense. In fact, the current that will produce the arc giving a light equivalent to 1,250 candles will only, in raising a platinum wire to incandescence, produce about 500 candles.

There are reasons to believe that light by incandescence will prove an extremely valuable light in future notwithstanding this deficiency, for whereas as in the arc the intensity of the light only increases directly as the current, in the case of incandescence it increases as the square of the current, and, therefore, there must be some point where the light produced by incandescence must equal that produced by the arc.

The reason why this is not attained is that no substance is yet known that will withstand the heat of the arc. Therefore, the electric light is almost a chemist's question, and the question to be solved is to find a material that will be a temperature of about 4,000 degrees Fahrenheit without fusion.

There is no apparent limit to the intensity of light produced by the electric arc, but you can have too much of a good thing, even of the electric light. The law of reduction of intensity, by which light diminishes as the square of the distance, renders it a wasteful form of energy; for if you have to illuminate a spot at some distance you must necessarily waste an enormous amount of light near at home.

Thus, in the various systems of lighting we have to consider the best mode of applying the light. Whether it shall be centralised in one spot, or whether it shall be distributed over a given area. Now, inasmuch as the electric light only utilises a little less than one half of the energy of the steam engine producing the currents, and as this share of the energy diminishes with great rapidity when resistance or lights are introduced, it follows that the only proper mode of economically using the light is to centralise it, *i.e.*, to have one engine producing one light. To attempt to subdivide the light is a wasteful process. Light subdivided in series is diminished as the square of the number of lamps inserted, and when dealt with by a parallel arc it diminishes as the cube of the number of lamps.

The electric light possesses several defects. For instance, it throws very deep shadows, it is accompanied by great flickering and hissing, and in all the lamps hitherto practically employed its durability is very short. On the other hand, it possesses great advantages. It is most brilliant. It is as pure as, if not purer, than the sunlight. By withdrawing from the atmosphere of places in which it is used the results of the combustion of gas and other artificial illuminants it adds considerably to the hygienic properties of the space in which it is employed. It produces neither smoke nor noxious vapours. Again, by removing the hot air which ascends from all gas lamps, especially such as that produced by the footlights at the theatre or opera, it improves considerably the acoustic properties of the space where it is, and it is impossible to conceive a greater reformation in our theatres than to supplant the present objectionable row of footlights by electric lights of some kind or other. It also, when centralised, is economical, and the results of all experiments have been to show that in such instances it can be used at a rate lower than the present cost of gas.

Every practical application of science passes through three distinct stages. First, we have the theoretical stage, where it is the dream of the philosopher. Secondly, we come to the tentative stage, where it is handled by the practical man and becomes the dream of the capitalist. And lastly, we have the practical stage, where the engineer attempts to realise the dream of the capitalist to benefit the public and add to the comforts of the world at large.

The electric light is scarcely out of the tentative stage. It is true that Messrs. Siemens have issued no less than 475 machines, and the Gramme authorities in Paris have issued over 1,000. Thus there must be some places where the light is permanently and practically in use, but it is still in the experimental stage, at least in England. It has been tried in workshops, in warehouses, in factories, in mills, in dye works, at railway stations, at docks. It is used in music halls, in circuses, and in illuminating, as we all know, the Thames Embankment. Its condition in this Hall is simply tentative, and—one must say it with great regret—it has met here with objections from a source whence one would scarcely anticipate obstruction. The chief opponents to its use are the ladies; the light is too pure for them; their eye and taste have been educated to meet the prevailing effect of the glow of gas-light; then, when upon their costumes the purer light of electric arc is thrown, disappointment is the result. Nevertheless, let us hope that the eye which has been once satisfied with the ample curvilinear outline of crinoline, and is now proud of the less ample but perhaps more beautiful curvatures, can readily and rapidly pass from the imperfection of gas-light to the purity of the electric arc.

One word as regards the future of this light. We have reached almost perfection in the machines designed for the production of currents, but during the last twenty years we have scarcely advanced one step towards an improvement in the electric lamp. The electric lamp of the future remains to be invented. Ideas as to its distribution are as futile as those regarding the philosopher's stone and perpetual motion; and with our present knowledge it is impossible to say that anything which has yet been produced is at all likely to supplant gas for domestic and ordinary purposes. Still, the electric light itself is well adapted for the illumination of large symmetrical places, and the result of the experiments of the past twelve months have been to show that it is only in this direction, in addition to the illumination of lighthouses and for naval and shipping purposes, that the electric light can be said to have maintained its own. The present exhibition is purely illustrative. It is in no way

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competitive. The various exhibitors have gratuitously brought their instruments here for illustration only, and by their help we had before us the greatest display of electric light apparatus that have ever been brought together in this world.

POTENTIAL—GRAVITATIONAL, ELECTRIC AND MAGNETIC.

BY L. CUMMING, M.A.

Our knowledge of physics is a knowledge only of the forces exerted by matter under a variety of conditions. When we find that the movement of a material body is resisted, or work has to be done in moving it from one position to another, independently of the resistance of the medium in which the motion is made, we gain a knowledge of the force of gravitation, and any space throughout which such resistance occurs is called a field of gravitational force. If the resistance to motion only occur when the body is in a peculiar condition, called electric or magnetic, we obtain in the same way an electric or magnetic field of force. Moreover our knowledge of gravitation, electricity and magnetism is entirely bounded by our knowledge of the actions exhibited by matter under these various conditions in their respective fields of force; so that an investigation of their properties is an investigation, not of the matter itself, but only of its field of force.

It may be objected that any two or three of the states alluded to may coexist in the same matter. This is nearly always the case, and it is only by obtaining matter in which the three states are developed in different degrees that we can eliminate the effects due to any two of them and get a clear conception of the part played by the third. Thus by a process of abstraction we come to consider matter as endowed with the forces of gravitation, electricity, and magnetism each separately from the rest, though their separation can certainly never be realised in the concrete form.

1. *Strength of Field.*—For the present, we will speak of these three conditions of matter in virtue of which it exercises force as *matter*, and shall denote, "by quantity of matter," that upon which force is exercised in the field of force which may equally be gravitational, electric, or magnetic—the matter being supposed gravitational, magnetic, or electric, according to the nature of the field of force. (Of course I am not implying that magnetism and electricity are material). The force at any point in the field of force depends on the quantity of matter placed there—for the conception of force is impossible unless applied to matter. If, however, we make an agreement as to the definite quantity of matter which shall test the field of force, the strength of the field at any point may be defined by the force experienced by that quantity of matter when placed at that part of the field. We call this quantity one unit of matter, and the force which a unit of matter experiences when placed at any point of the field is called the strength of the field at that point.

Thus to find the strength of the gravitation field of the earth at different places on or above it we take a definite mass we call a pound or a gramme (for, of course, the so-called units of weight are really units of mass), and find, by means of a spring balance or otherwise, the force it experiences at each place.

To find the strength of the magnetic field of the earth at any place, we take a certain magnet, each of whose poles contains a unit of magnetism, and find the force each of its poles experiences at the place.

2. *Lines of Force.*—Since the unit of mass placed at any point in a field of force experiences force, it will, unless resisted, tend to move in a certain definite direction. This direction is called the line of force through that point. Through each point in the field there will be one line of force, and there can be only one since a body never tends to move in either of two or more directions equally, but always definitely in one direction, unless constrained to follow some other. Hence to every point in a field of force belongs one and only one line of force.

Thus the direction in which a free particle tends to fall (or the plumb line) will give the direction of the line of force at any point due to the earth's gravitation, and the direction assumed by a dipping needle gives the direction of the line of force of the earth's magnetism.

To define a field of force, we must know the direction of the line of force at each point in the field, and the strength of the field at each point.

3. *Difference of Potential at two points.*—If any two points A B be taken in a field of force, and a unit of matter be carried from A to B against the force in the field, a certain amount of work will be done on the unit, and if the unit of mass be allowed to pass back from B to A by frictionless constraint, the particle will acquire an amount of energy in its fall. The principle of conservation of energy shows that the amounts must be equal, and also that the amounts of work or energy will be the same, whatever path be pursued from A to B or from B to A respectively.* For if more energy were acquired in falling along a path B C A, than along another path B D A, then by allowing the particle constantly to fall along B C A, and to return along B D A, we should have an unlimited source of energy.

The work done in passing by any path whatever from A to B in the field of force is defined to be the difference of the potentials at the points A and B. This is now seen to depend only on the positions of A and B in the field of force.

Thus the difference of potential for two places near the earth's surface will be expressed in foot-pounds or cm.-grms. respectively by $32{\cdot}2\,h$ or $981\,h$, where h is the difference in height above the sea level in feet or cms., the force of gravity being assumed that at the sea level about the latitude of London. The standard from which h is measured is plainly arbitrary, as we are only concerned with the difference—practically though it would be the sea level, and we might speak strictly of places above the sea level having positive, or below the sea level negative potential.

Though heat does not, as far as at present known, fall under the category of physical forces we are now considering, the quality called temperature is strictly analogous to potential. When we speak of the temperature of a certain place near a hot body, we only give the difference between its thermal condition and that of ice cold water, the ice cold water being a standard arbitrarily chosen on account of its convenience of reproduction. Or if the measure is given in Fahrenheit degrees, it is referred to the standard of a mixture of salt and snow. Generally we are no more able to give an absolute measure of potential than we are able to protrude our thermometer bulbs into interstellar space to find an absolute zero of temperature. But no confusion will arise if we keep before us that we are not giving the potential at a point *absolutely*, but only the difference between the potential at that point and at another we have before agreed upon. The absolute zero is, however, at an infinite distance from all attracting matter, just as the absolute zero of temperature is that of interstellar space.

4. *Force in Terms of Potential.*—Take any two points, A B, in the field, and call their difference of potential V. Then if F be the average force along A B, we have $F \times AB = V$, or $F = \frac{V}{AB}$. Hence the average force along any line will be given by the average rate at which potential changes along the line, and if the line be made very short, we may say that the force at any point, in any given direction, is the rate of change of potential at that point in the given direction. Since the resultant force at the point is given by the direction of the line of force, and the force in any other direction will be the component in that direction of the resultant force, it follows that the potential changes most rapidly along the line of force, and less and less rapidly in directions more and more inclined to the line of force, while in a direction at right angles to the line of force the rate of change of potential must vanish.

This may be illustrated from gravitation. At any point on an inclined surface the line of force will be the line of greatest slope, or the line along which potential changes most rapidly, while perpendicular to this line will be a horizontal line or line of no change of potential.

5. *Equipotential Surfaces.*—If a surface be drawn through the field of force, which everywhere cuts at right angles lines of force, the rate of change of potential along it will be zero, or the surface will be an equipotential surface, and the force resolved along it at any point will always vanish, so that no work is done in moving matter along an equipotential surface. Due to the earth's gravitation the surface of the sea is an equipotential surface, or the surface of any plain as determined by the spirit level or a plumb line.

6. *Mapping a Field of Force.*—Since through every point in a field of force equipotential surfaces can be drawn, and no two equipotential surfaces can intersect (for if they do they belong to the same equipotential surface), we can draw in the field a system of equipotential surfaces such that the difference of potential between any two points on two consecutive surfaces, shall always be the same (say one foot-pound or cm.-grm.). We can now with propriety speak of the value of the potential of any one of these surfaces, denoting by it the difference between the potential at any point on it, and at a certain point which we have chosen as our provisional zero. When the field of force has been mapped out by equipotential surfaces the line of force at any point will be normal to the surface, and the force at any point will be inversely proportional to the perpendicular distance between this surface, and that next to it.

7. *Number of Lines of Force.*—If the forces be such as occur

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* Making a single reservation in the case of Electro-Magnetism.

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in nature, there is a more convenient way of expressing the strength of the field at any point. Suppose a distribution of lines of force over any equipotential surface such that the closeness to each other of the lines of force round any point gives a measure of the strength of the field at this point, so that the number of lines of force per unit area near the point, is proportional to the strength of the field at that point. If a distribution of lines of force satisfying this condition be made on any one equipotential surface, and no new lines of force come into existence in the field, then the same proposition will hold true for the distribution of force over any other equipotential surface cut through by these same lines of force. The force at any point will have the same proportion to the number of lines of force per unit area near that point on the new equipotential surface, and this constant proportion is usually spoken of as a unit. On this hypothesis the number of lines of gravitational force will be be 32·2 per square foot on the English system, or 981 per square cm. on the cm.-grm. system for a place at the sea level in the latitude of London.

It will at once be seen that, given any one equipotential surface and the force at each point on it, all other equipotential surfaces can be found in a geometrical manner without consideration of the system of matter which gives rise to the field of force.

8. *Potential of one body on another.*—If there be a quantity of matter m at a point where the absolute potential, due to a certain system A is V, then m V units of work will be done in moving m out of A's field of force. Theoretically, the matter must be moved to an infinite distance from A; but the only thing necessary is that the distance shall be so great that the force due to A's field is imperceptible to the instruments at our disposal, as then all the propositions deduced will be *sensibly* true. To carry calculations beyond the point where our limits of observation cease would be as futile as, for instance, to calculate, from astronomical data, the distance of the sun to decimals of an inch. Any material body B may be conceived as an assemblage of quantities of matter collected at geometrical points, and if for each such quantity the product m V be calculated and all such products added together, the sum (denoted by $\Sigma\, m\, V$ or $\iiint V\, dm$) will clearly be the work done in moving B out of A's field of force. This may be called the potential of A on B.

Conversely, if we consider B's field of force, and take the potential due to B at each point in A (V′ suppose), and take the quantity of matter (m') at this point, then the sum ($\Sigma\, m'V'$ or $\iiint V'\, dm'$) will be the potential of B on A, or the work done in moving A out of B's field of force. The third law of motion shows that these quantities of work must be the same when the same relative path is pursued, and the principle of conservation of energy shows that it is independent of the path pursued. Hence we may say generally of any two systems whatever, the potential of A on B is equal to the potential of B on A.

In the foregoing we have endeavoured to fix attention on the field of force, and not on the matter which brings this field into existence. The only assumption made is that the forces are directed towards fixed centres, and vary inversely as the squares of distances from these centres; and since these are experimental laws for the conditions or properties of matter called gravitation, electricity, and magnetism, the propositions as to the mapping the field of force by equipotential surfaces and lines of force will hold for each of them. We now proceed to apply them to statical electricity.

The fundamental properties of statical electricity are two—

(1) Its dual nature. We cannot have a quantity of vitreous or positive electricity without having at the same time an equal quantity of negative or resinous electricity. The forces exerted on these quantities are equal but are directed in opposite directions. For this reason we define the positive direction of a line of force as the direction in which a quantity of positive electricity placed anywhere on the line will tend to move.

(2) In regard to electricity, all bodies may be classed as either conductors or insulators, the latter being also called dielectrics. The characteristic distinction between these two classes is that every field of force must consist wholly of dielectrics, as experiment proves beyond doubt that within the substance of a conductor there can be no electric force, and, therefore, no electric field. Every electric field is therefore bounded by conducting surfaces. Experiment also proves that in a hollow conductor there is still no electric force unless there be conductors within it insulated from it by a dielectric, in which case there will be a field of force within the conductor (but altogether independent of that outside it) only if these second conductors be in the condition called electric. From this it at once follows that there being no electric force within a charged conductor, there can be no change of potential, or, in other words, every surface bounding a conductor, as well as the whole space enclosed by the conductor, must be equipotential, and all lines of force cut the surface at right angles.

(TO BE CONTINUED.)

RECENT PATENTS.

2816. MAGNETISING METAL OR OTHER SUBSTANCES, &c., *G. E. Pritchett. Dated 13th July*, 1878. 6*d*.

Thin plates of hardened steel are magnetised and bent to any required shape, several of them being secured together, thus obtaining a stronger magnetic field than could be obtained by using solid thick plates. In combination with these plates, one, two, or more pieces of carbon or other suitable material may be introduced in such a manner as to assist the transmission or reception of sounds.

3217. TRANSMISSION OF SIGNALS BY ELECTRICITY, *W. R. Lake.—Dated 14th August*, 1878.—(*A communication*).—(*Not proceeded with.*) 4*d*.

The rails upon which the trains travel are used as an electric conductor, and the right-hand wheels of the carriage are insulated from the left-hand wheels, as the current has to travel by one rail and return by the other.

3315. APPARATUS FOR ELECTRIC LIGHTING, *C. W. Siemens.—Dated 22nd August*, 1878.—(*Void*). 2*d*.

At the top of two insulated standards metal tubes are fixed, through which the carbon rods pass. At the bottom ends of the tubes two or more sets of rollers are placed, the carbon rod passing between them and being fed forward by the rollers, which are caused to revolve by a clock-work movement. The end of each carbon is hollowed out, and the back end is conical, so that as the rod in use advances a fresh one may be supplied by applying a cement to the conical end of another rod and pressing it into the hollow of the former rod.

3317. GALVANOMETERS, *E. A. Obach.—Dated 22nd August*, 1878.—(*Not proceeded with.*) 2*d*.

Instead of making the meridian ring or coil fixed, it is mounted on horizontal bearings, one at each side of the needle dial, or on a separate frame parallel thereto, so that it can be turned to various degrees of inclination from the vertical.

3804. SPEAKING TELEPHONES, *J. F. Bailey.—Dated 27th December*, 1878.—(*A communication.*)—(*Complete.*) 6*d*.

This consists in combining in an electric circuit a telephonic apparatus capable of transmitting articulate speech with a resonant receiver through the intervention of animal tissue in gliding or frictional contact with said resonant receiver. This receiver may consist of a plate of any of the well-known metals capable of induction or not.

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Companies.	Closing Prices May 7.		Business Done Week Ending May 7. Highest.		Lowest.	
Anglo-American	55¼,	6	57		55¼	
Do. "B"	85½,	¼	86½		85½	
Do. "A"	27½,	¼	29		27½	
Brazilian	6¼,	¼	6¼		6¼	
Cuba	8,	¼	8¼		8¼	
Do. Ten per Cent. Preference	15½,	16½	15½		15½	
Direct Spanish	1¼,	2¼	—		—	
Do. Ten per Cent. Preference	10½,	¼	—		—	
Direct United States	10¾,	11	11¼		10¾	
Eastern	7⅞,	⅛	7⅞		7⅞	
Do. Six per Cent. Debenture	104,	7	105¼		105¼	
Do. Five per Cent. do.	102,	5	104		102¾	
Do. Six per Cent. Preference	11¼,	12	11¼		11¼	
Eastern Extension	7 9-16,	11-16	7⅝		7⅝	
Do. Six per Cent. Debenture	106,	9	—		—	
German Union	7⅞,	8	—		—	
Globe Telegraph and Trust	4¼,	5	5		4 15-16	
Do. Six per Cent. Preference	10 13-16,	15-16	11		10¾	
Great Northern	8¼,	⅛	8¼		8¼	
Indo-European	20¼,	1¼	20¼		20¼	
Mediterranean Extension	2¼,	3	—		—	
Do. Eight per Cent. Preference	9¼,	10	—		—	
Reuter's	9¼,	10¼	—		—	
Submarine	220,	230	—		—	
West India and Panama	1⅛,	⅛	1 9-16		1 7-16	
Do. Six per Cent. Preference	8¼,	¼	8¼		8 11-16	
Western and Brazilian	3¼,	4	3¼		3¼	
West. Union Seven per Ct. 1st Mt..x d.	111,	114	—		—	
Do. Six per Cent. Sterling	102,	104	—		—	

TRAFFIC RECEIPTS FOR APRIL, 1879.

Companies.	April 1879.	April 1878.	Increase.	Decrease
Anglo-American Telegraph Company	45,540 estd.	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,000 estd.	2,940	60	—
Direct Spanish Telegraph Company	803	746	57	—
Direct United States Telegraph Company	15,790	—	—	—
Eastern Extension Telegraph Company	21,060	21,753	—	693
Eastern Telegraph Company	37,846	32,210	5,636	—
Great Northern Telegraph Company	16,299	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company.	—	—	—	—
Western and Brazilian Telegraph Company..	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

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NOTES.

SWEDEN.—The revenue from telegraphs was less than was estimated last year. The amount received was about £78,000; the estimate for the current year is £73,000.

IRISH TELEGRAPH CLERKS.—Lord J. Manners, in reply to a question in the House of Commons, said the memorial from the telegraph clerks in the Dublin Post Office for an increase of pay was now under the consideration of the Government.

ORANGE FREE STATE.—Mr. Miles, in a letter to *The Times*, says: "Last year, when it was necessary to raise enough money to pay for the telegraph line from Fauresmith, a poll-tax of £1 for whites and 10s. for natives was imposed, which was calculated to bring in £40,000; but it only produced £1,800."

PROTECTION OF BINDING SCREWS, &c., FROM RUST.—In a recent communication to the Berlin Chemical Society MM. Beilstein and Sawein describe a simple means of preventing Battery terminals and wires becoming corroded. It is stated that they are kept bright and clean for a very long time by lubricating them with Oleonaptha—an oil prepared from Caucasian Petroleum.

FURTHER DEVELOPMENT OF ELECTRIC LIGHTING!—We notice that some enterprising Publicans are illuminating the exterior of their premises with the Electric Light. A form of Bunsen's Battery is said to feed the lamp; but the real motive power, to the best of our observation, is behind the Bar, where the engines are kept constantly going, by reason of the uncontrollable thirst which seizes the spectators after a brief period of open-mouthed wonderment outside.

FRANCE.—The result of the postal and telegraphic reform, dating from the 1st May, 1878, has been that there is, as was to be expected, a large deficit in the former item. It amounts to £584,000. But, on the contrary, the returns show a surplus in the item for telegraphs amounting to £64,500. It thus appears that the new rate for telegrams has been appreciated by the public, and has at the same time added to the revenue. The estimated receipts for the current year from telegraphs is £847,080.

SIEMENS' ELECTRIC LIGHT.—Undoubtedly the most effective, and perhaps the most important, of the electric lights exhibited at the Albert Hall on the 7th and 8th inst. was the "electric sunlight" of Messrs. Siemens Brothers, which occupied the centre of the dome in this great building. The most pleasing feature of this "sunlight," constituted by five Siemens lamps, yielding in the aggregate an illumination equal to that of 35,000 standard candles, was its unobtrusiveness. The flood of slightly-golden light was everywhere; the lamps themselves could be observed only by gazing aloft. We have characterised the light as "slightly golden;" the somewhat cold and apparently blueish tint of the ordinary electric light was in fact corrected by the device of gilding the "sunlight" reflectors. The light was surrounded by a shield of gauze—not, as was commonly supposed, for the purpose of catching any minute incandescent particles which might drop from the lamps, but mainly to obviate the effects of draughts of air upon the latter. The only drawback we could observe in this beautiful illustration of the capabilities of electric lighting was the noise made by the regulators of the lamps, which at one time was quite sufficient to interfere with certain of the musical effects produced at concerts. But, amongst the lamps exhibited, the Siemens lamp is not that which is most open to this objection.

TELEGRAPHY.—Mr. W. H. Preece, of the Postal Telegraph Department, gave the fourth of the Cantor Lectures on Telegraphy at the Society of Arts on Monday night; Lord Alfred Churchill in the chair. The lecture was devoted to a description of quadruplex and duplex systems of working. There are in England 320 duplex circuits at work, and the aggregate mileage of wire so worked is over 40,000 miles. Various systems of duplex working were described, and it was mentioned that Mr. Stearns, to whom the principal credit is due for the introduction of this system, had succeeded in duplexing the Atlantic cable at the rate of twenty words of five letters each per minute in each direction. The disturbing influences, such as temperature, earth currents, thunderstorms, &c., and the means taken to obviate their bad effects were described. Connected with the development of duplex work were Gintl (1853); Frischen (1854); Siemens and Halske (1854); Stearns (1868); and, as having done special work connected with cables, Muirhead. There are six circuits filled with quadruplex apparatus in England, but in America there are sixty-three circuits, over which the Western Union Telegraph Company send eight million messages per annum. Mayer and Baudot's system of multiple telegraphy, as well as the system of harmonic telegraphy, invented by Cromwell Varley in 1870, and practically carried out by Elisha Gray in America, were described. The systems of duplex and quadruplex working were shown in actual operation over a wire connecting the room of the Society of Arts with the central telegraph station. Many messages were sent to and fro, and the audience evinced great interest in the system.

APPARATUS OF M. JAMIN FOR THE ELECTRIC LIGHT.—M. Jamin surrounds two nearly parallel carbon sticks, as employed by Mr. Wilde of Manchester, with an elliptical coil of wire through which passes the current which gives the light. This coil, being in the same vertical plane as the carbon rods, is arranged so that the current through it is in the same direction as that which flows through the latter, producing the arc at their extremities. In virtue therefore of the law that currents in the same direction attract and those in opposite directions repel each other, the currents through the upper portion of the coil will attract the arc and those through the lower portion will repel it. The lateral currents also, by reason of their tendency to deflect the arc into parallelism aid in repelling the latter to the extremities of the carbons So powerful is this effect of repulsion that, if the number of turns of wire in the coil be too great, the arc, if caused to pass between the lower portions of the carbon rods, will move upwards with great velocity, and the light becomes extinguished, owing to the arc being too strongly attracted in the direction of the extremities of the carbons. With this apparatus, the arc becomes strongly curved; and it is stated that the light evolved is very considerably augmented by its use, owing to the carbons being no longer consumed laterally, so as to shade the light. By using this apparatus, also, the lamp may be reversed, without any danger of the arc

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quitting the extreme ends of the carbon rods. These appear to be important advantages gained in the solution of one of the main questions in connection with electric lighting.

Submarine Telephony.—Mr. Raymond, an engineer in New York, recently read a paper before the Society of Engineers in New York, in which he described some improvements he had made in using telephones in diving operations. The arrangements first employed consisted of two Phelps telephones, which, being oval and flat, are convenient for this purpose. One of these was fastened in the diver's helmet, in such a position that by simply turning his head the diver could place his mouth or his ear to the instrument. The other was placed on the scow which carried the assistants and the air-pump; and the two were connected by means of insulated wires inside the air-hose. This was found to work very well, so far as communication from the diver to his helper was concerned; but there was difficulty in sending messages the other way, since the bubbling of the air as it escaped from the helmet into the water interfered with the diver's hearing of the telephone. This difficulty was overcome by the use of Edison's "carbon-transmitter," which rendered the sound so much more audible that conversation could be carried on with the utmost facility. It was found that the diver could talk in the helmet without putting his mouth to the instrument, and be heard plainly, so that work and conversation could go on at the same time. In the discussion upon Mr. Raymond's paper, it was asserted that the cost of the necessary outfit for telephonic communication of this sort would be about one hundred dollars, and that, on the other hand, the work of a diver with ordinary means of communication costs about three dollars per hour. The saving of time effected by this means of quick and full transmission of intelligence would evidently soon repay the original outlay.

The Electric Light.—American papers just received state that Mr. Edison is still engaged in his experiments with reference to the electric light, and hopes yet to overcome all difficulties and to make the light available for general use. In a recent interview with a reporter, Mr. Edison, pointing to a number of lamps of Wallace's pattern which hung near the ceiling, said,—"In a short time I am going to light those lamps by the Wallace machine, by the Gramme machine, and by my machine, and anybody can come here, watch the process, and draw conclusions as to the relative economy of each generator." "Why do you intend to employ the carbon lamps for purposes of illumination instead of your incandescent lamps?" asked the reporter. "Because everybody knows what the carbon lamp is, and, besides, because it is not my lamp." "How many carbon lamps can you light with one machine?" "I do not know. That is to be one of the tests. I am going to put as many lights in a circuit as each machine will stand, and then we will see how my machine will come out." Being questioned as to the subdivision of the electric light, the inventor said, "The question is very simple. If you take a lamp in which the voltaic arc is produced from two carbon pencils, the more current you put on the faster the pencils are consumed and the resistance offered is lessened. There necessarily results a great waste of power. If the lamp is limited to 250-candle light, it costs too much. By my plan the resistance is almost entirely at the lamp. The resistance of the conductor is to the resistance of the lamp as 1 to 100. The resistance of my lamp is as 192 against 1 to the resistance of the carbon lamp. You may consider the question most intelligently by taking a gas-burner as an example. If you have a half-inch gas-pipe and light the escaping gas without putting on a burner, how much gas-light can you get from an adjoining burner? Very little. But if you put in the half-inch pipe a burner, with a pin hole in it, you get a light without interfering with other burners. The same condition obtains in electric lighting. The carbon lamp represents the half-inch gas-pipe; the pinhole burner represents my lamp." "But is not the electric current exhausted, not with regard to the resisting agent, but according to the square of the distance travelled?" "No. If you are supplying a mile of wire and then add another mile, the current will be weakened equally throughout the whole line, but not to that extent. If you keep on extending your line, you will have to make your conductor thick and add more power." "How do you propose to carry this theory into effect?" "I shall have, proceeding from the central station, where a steam engine and a series of dynamo-machines are placed, a cable, say about an inch in diameter, composed of copper wires, each about one-sixteenth of an inch in diameter. The cable will be laid in a trench immediately under the flagging of the side walk, and near the curb; every 25 feet a wire will be dropped to carry the current into a house, and when the terminus of the cable is reached there will be one wire left. Of course it will be necessary to construct the cable according to the number of houses in each district. As a district increases in population, the flagging can be taken up, and a section of cable can be placed alongside the original cable, and joined to it at each end. Thus the new houses can be supplied." "Will there not be a loss of electricity by induction or the influence of the earth?" "None whatever. And now I will tell you another thing. It is perfectly easy for me to get a light equal to sixty-six candles from each of my lamps; but I limit them to six." "Will not the construction of your station and your cables be very costly?" "No; and if it were, the profits would warrant the outlay." According to the American papers just received at Cork, Mr. Edison has perfected his dynamo-electric machine, and with that, he says, he has solved the problem of the economical generation of electricity and the subdivision of the light. The machine was tested on the evening of May 2. Wires were connected with five of Wallace's voltaic lamps, and the moment steam power was applied the lamps were lit. The machine did not become hot, but it gave off a few sparks. The lamps gave a steady light, although currents of air were not excluded, and the five lamps were lit with one machine with one-half of 1-horse power for each lamp. The experiment, although imperfectly made, was entirely satisfactory, and showed that Edison's generator would allow of nine lamps in a circuit, or would develop more dynamo-electric power per horse power than any machine yet constructed. The advantages of Edison's machine, so far as they have been demonstrated, consist in obtaining a great amount of electricity with the development of little heat. The transmitted power is, therefore, almost entirely converted into electricity. These results are obtained by getting a larger magnetic field and employing a superior method of winding the bobbin with the insulated wires. Edison will now have 30 of these machines constructed for the formation of his model station, which will probably be at Menlo Park. It is estimated that he can get at least 400 lights by means of his 80-horse power steam engine and 30 of his dynamo-electric machines. He will now devote his time to producing a lamp which will be without flaw.

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POTENTIAL—GRAVITATIONAL, ELECTRIC AND MAGNETIC.

BY L. CUMMING, M.A.

(CONCLUDED FROM PAGE 300.)

1. *Electrification.*—The boundary of a conducting surface in an electric field is an instance of discontinuous force, since at a point outside the surface there is a finite, measurable electric force, while at a point as near to it as ever you please inside the surface there is no electric force whatever. It is this discontinuity of force in the field that is generally termed electrification of the surface, the electrification being said to reside only on the outside. We must, however, in strictness remember that of the condition of the body under which this discontinuity is manifested we know nothing; all that we express by the phrase electrification of a conductor being the development in the conductor of a state which results in the discontinuity we have noticed.

2. *Field of Electrostatic Force.*—In the case of a single conductor, the field of force is bounded by the walls of the room in which the experiment is performed (or by the surface of the earth when the experiment is performed in the open air), both the earth and the walls of the room which constitute part of it being on the whole conductors. Now Faraday's icepail experiment shows that the electricity on the surface of the room is always equal and opposite (*i.e.*, complementary) to that on the body suspended inside it, and the lines of force, therefore, proceed from the charged conductor to the walls of the room, both surfaces being equipotential and both being cut at right angles by the lines of force. The field of force consists only of the air between the surface of the charged conductor and the walls of the room, there being no alteration whatever in any external field of force by the electrical separation made within a closed space; in fact, the closed conducting surface made by the walls screens completely from each other all electrical forces respectively, external and internal to it.

3. *Zero Potential.*—Since the walls of the room form part of the earth, which itself is a conductor, they will be at the same potential as the earth. The whole difference of potential in the field will, therefore, be that between the surface of the conductor and of the earth. We, therefore, make the convention that the potential at any point within a cavity in the earth is the difference between the potential at that point, and at any point in the earth. It may be objected that we do not know whether the potential of the earth is a fixed standard at different times, but this is of no consequence, as any alteration in the potential of the earth will be the same throughout it, and the potential of our electrified body suspended within the earth, and of the earth itself, will be raised or lowered by the same amount, the difference being unaltered. In fact, the work done on a measured quantity of electricity brought up from the walls of the room to the charged conductor is the same as the work done in bringing it up from an infinite distance to the same conductor, since the force outside the room is *nil*, and, therefore, the whole work will be *nil*—assuming that the electrical separation we have made is the only one in the universe.

4. *Electrostatic Potential at a point.*—The mathematical measure of potential at a point in a field of force is the work which would be done on a certain quantity of electricity when brought up from an infinite distance to the point. The function of the negative complementary distribution on the walls of the room being to increase the whole work done in the field by the amount which would, *theoretically*, be necessary to bring up the testing quantity from infinity to the outside of the room. Now, all electrical experiments are performed in cavities of the earth; since, if even apparently performed in the open air, the electrometers are surrounded by cases which are conducting surfaces, and form part of the earth. The only exception being that of atmospheric electricity, where the quantity really measured is never the potential of the earth, but the rate at which potential changes as we ascend from the earth, or, in other words, the strength of the electric field. If, however, we were to make experiments *bonâ fide* in the open air by electrifying a conductor and allowing the complementary charge to escape to earth, after making allowance for the electric field of the earth, it is easy to prove that the error introduced into our calculations will in every practical case be insensible.* In this case, also, the potential at a point will be sensibly equal to the work done in bringing up a certain quantity of electricity from the earth to the point.

5. *Potential of a Conductor.*—Since the surface and interior of a conductor has at every point the same potential we may now define this potential as the potential of the conductor.

* The error is really of order $\frac{h\,c}{R^2}$ where c is the capacity of the conductor, h its distance from the earth, and R the radius of the earth.

The analogy noted above between potential and temperature is very noticeable in relation to electrostatic potential. Just as temperature at a point expresses a certain condition in relation to heat, so electrostatic potential at a point expresses the condition at that point in relation to electricity. Just as we should pass through our lives without any sensible knowledge of temperature if we always lived in a medium whose temperature was the same or sensibly the same as that of our own bodies, so we do pass through our lives without any sensible knowledge of potential, because we and our surroundings are always at the same potential as the earth. If our bodies are ever in a region where there is a rapid change of potential, we become aware of it by the erection of our hairs, by a tickling sensation on our skin, and by giving off of sparks when we approach bodies at different potential to our own, and by a shock through our nervous and muscular system (which often results in death) if for an instant different parts of our bodies are at a large difference of potential. It is only the property that all conductors are equipotential throughout that makes the appeal to the senses less understood in electricity than in heat.

6. *Unit quantity of Electricity.*—The definition of this unit usually given is a quantity of electricity which, when condensed in a point, at a unit of distance from another equal quantity of electricity exerts a unit of force. This, of course, is a purely abstract definition, as no finite quantity of electricity can ever be condensed in a point. It may be taken as expressing the experimental fact that the law of inverse squares never holds absolutely in experiments, but is more and more nearly true the smaller the conductors are, and sensibly true when the conductors are very small indeed. It may be noticed that quantity of electricity is only a measure of quantity of electrical force just as matter is really measured by the force excited on it in a given field which is assumed constant.

7. *Density at a point on a Conductor.*—Since there is no force inside a conductor it is easily seen that the force just outside it at any point will depend on the (assumed) electrification of the surface near to that point only. The quantity of electricity per unit area near that point is usually defined to be the electrical density at the point. It is an expression of the state of the surface on the hypothesis of its electrification exactly similar to that expressed by the number of lines of force per unit area at the boundary of the field of force, and it will be seen in a particular case that the numerical ratio between the number of lines of force at a point on the surface bounding the field, and the density of the electrification at that point is 4π, a relation which always holds true. Since lines of force always proceed from the positive to the corresponding negative electrification, it follows that the whole number of lines of force must be the same on both. It also follows that if a tube be constructed bounded by lines of force, the whole number of lines of force which are enclosed by the tube on the positive and negative surfaces respectively will be the same, or the number of lines per unit area is inversely proportional to the area; that is, the density of the electrification on the two surfaces is inversely as their areas, and the quantities of electricity are, therefore, the same on both.

8. *Capacity of a Conducting System.*—Taking the case of a conductor insulated in a cavity, we will now, for brevity, speak of the conductors' surface as an inner coat, and the surface of the cavity as an outer coat of the field of force. It is plain that for a given difference of potential, the force in the field will be greater the nearer the inner and outer coats are together. If under given conditions a certain difference of potential corresponds to a certain number of lines of force or quantity of electricity, double that difference will correspond to double the number of lines of force, and so on. It is the fixed numerical ratio between the quantity of electricity on the two coats, and the difference of potential between them which is called the capacity of the system. If the distance of the outer coat be made several times the whole diameter of the inner coat no further increase affects sensibly the capacity of the system. In this sense we speak of the capacity of a conductor in space, which is only meant to express that all other conductors are so far removed that their influence is insensible.

9. *Induction.*—If an insulated conductor be introduced into a field of force, its surface becomes at once equipotential, by what is known as an inductive electrification. The effect of this induction will be to alter all the equipotential surfaces and lines of force in the field. If, however, the conductor be at a considerable distance from the electrification which gives rise to the field of force, we may neglect the disturbance in the field except near the induced distribution. For simplicity suppose this to be the case, and also suppose the conductor a cylinder, placed with its length along lines of force. The potential at one end will be too high, and at the other too low, so that the body will assume a potential intermediate between these two values. Thus on the part of the cylinder at which the potential is too

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high a negative induced charge is developed, and on the part where the potential is too low there will be equally an induced positive charge. While there will be no electrification along a line (the neutral line) at each point of which the potential due to the original field is the same as the potential due to the original field and induced distribution together, or, in other words, when the potential of the induced distribution vanishes.

If the body introduced into the field is itself electrified, the same principle may be applied, but in determining the potential near it the potential due to its original electrification must be added, and in determining the resulting electrification we must add the density of its original electrification at each point to that determined at the same point for the same conductor assumed unelectrified.

10. *Specific Inductive Capacity.*—A curious perversion of ideas occurs in the usual treatment of electrification as something proper to the conductor, and not to the field of force surrounding it. This is shown by considering that the nature of the conductor is of no importance whatever, while the charge of the dielectric composing the field of force alters all our measures in the field. All we have said about the relations in the field will be true of whatever dielectric it is composed, but the unit quantity of electricity as defined above is different in different dielectrics; so that, if a given separation of electricities be made, and the difference of potential measured—in air, for instance—this difference will not be the same if a new dielectric be substituted, the potential difference being still measured in air. Of course, if the electrometer be also in the new dielectric the potential difference will remain apparently the same. It is this difference in behaviour of dielectrics which is expressed by their specific inductive capacity, and it was this observed difference upon which Faraday founded his well-known theory of electric induction, doing away entirely with the principle of action at a distance.

These principles enable us at once to write down the numerical relations between the measures of the various qualities we have named, thus :—

Quantity of Electricity as already explained is measured in a unit such that if condensed in a point it shall exert unit force on another unit also condensed in a point distant from it a unit of length. The measure of quantity in terms of this unit we denote by the letter q.

Density of Electricity.—Since it is assumed that electricity only exists on the surface of a conductor, the quantity of electricity per unit of area of surface at each point is defined to be the density. If electricity be distributed over an area s with uniform density ρ, we have for its quantity $q = \rho s$, or $\rho = \frac{d q}{d s}$ at a point.

Electrical force or strength of field at a point in a field of force is the force which a unit of electricity placed there would experience. The strength of the field close to a point on a conductor where the density is ρ is $4 \pi \rho$.

Electrical potential at a point in a field of force is the work done in bringing up a unit of electricity from the earth to the point. Its numerical value is found to be expressed by $\Sigma \frac{q}{r}$ or $\iint \frac{d q}{r}$ where this symbol denotes the process of summation all the quotients obtained by dividing the quantity of each element of the electrification by its distance from the point under consideration.

Electrical Capacity is a measure of the quantity of electricity required to raise the potential of a conductor under given circumstances by one unit. If q be the quantity of electricity on a conductor of capacity c, and potential V, then $q = c$ V.

A convenient illustration of several of these units is afforded by a sphere of unit radius, charged with unit quantity of electricity in a large room, or in free space. The electrical force and potential at every point on the surface are each unity, and consequently the number of lines of force per unit area, unity. The density is $\frac{1}{4 \pi}$ since a unit of electricity is distributed over an area whose measure is 4π. Since unit quantity raises the potential of the sphere from zero to unity, the capacity of the sphere is unity.

THE INFLUENCE OF ELECTRICITY ON COLLIDING WATER DROPS.*

BY LORD RAYLEIGH, F.R.S.

It has been known for many years that electricity has an extraordinary influence upon the behaviour of fine jets of water ascending in a nearly vertical direction. In its normal state a jet resolves itself into drops, which even before passing the summit, and still more after passing it, are scattered through a considerable width. When a feebly-electrified body is brought into its neighbourhood the jet undergoes a remarkable transformation, and appears to become coherent, but under more powerful electrical action the scattering becomes even greater than at first. The second effect is readily attributed to the mutual repulsion of the electrified drops, but the action of feeble electricity in producing apparent coherence has been a mystery hitherto.

It has been shown by Beetz that the coherence is apparent only, and that the place where the jet breaks into drops is not perceptibly shifted by the electricity. By screening various parts with metallic plates, Beetz further proved that, contrary to the opinion of earlier observers, the seat of sensitiveness is not at the root of the jet where it leaves the orifice, but at the place of resolution into drops. As in Sir W. Thomson's water-dropping apparatus for atmospheric electricity, the drops carry away with them an electric charge, which may be collected by receiving the water in an insulated vessel.

I have lately succeeded in proving that the normal scattering of a nearly vertical jet is due to the *rebound* of the drops when they come into collision with one another. Such collisions are inevitable in consequence of the different velocities acquired by the drops under the action of the capillary force as they break away irregularly from the continuous portion of the jet. Even when the resolution is regularised by the action of external vibrations of suitable frequency, as in the beautiful experiments of Savart and Plateau, the drops must still come into contact before they reach the summit of their parabolic path. In the case of a continuous jet the "equation of continuity" shows that as the jet loses velocity in ascending it must increase in section. When the stream consists of drops following the same path in single file no such increase of section is possible, and then the constancy of the total stream requires a gradual approximation of the drops, which in the case of a nearly vertical direction of motion cannot stop short of actual contact. Regular vibration has, however, the effect of postponing the collisions and consequent scattering of the drops, and in the case of a direction of motion less nearly vertical may prevent them altogether.

Under moderate electrical influence there is no material change in the resolution into drops, nor in the subsequent motion of the drops up to the moment of collision. The difference begins here. Instead of rebounding after collision, as the unelectrified drops of clean water generally or always do, the electrified drops *coalesce*, and thus the jet is no longer scattered about. When the electrical influence is more powerful, the repulsion between the drops is sufficient to prevent actual contact, and then of course there is no opportunity for amalgamation.

These experiments may be repeated with extreme ease and with hardly any apparatus. The diameter of the jet may be about $\frac{1}{20}$ inch, and may be obtained either from a hole in a thin plate or from a drawn-out glass tube. I have generally employed a piece of glass tube fitted at the end with a perforated tin plate, and connected with a tap by india-rubber tubing. The pressure may be such as to cause the jet to rise eighteen or twenty-four inches, or even more. A single passage of a rod of gutta-percha, or of sealing-wax, along the sleeve of the coat is sufficient to produce the effect. The seat of sensitiveness may be investigated by exciting the extreme tip only of a glass rod, which is then held in succession to the root of the jet and to the place of resolution into drops. An effect is observed in the latter, but not in the former position. Care must be taken to use an electrification so feeble as to require close proximity for its operation, otherwise the discrimination of the positions will not be distinct.

The behaviour of the colliding drops becomes apparent under instantaneous illumination. I have employed sparks from an inductorium, whose secondary terminals were connected with the coatings of a Leyden jar. The jet should be situated between the sparks and the eye, and the observation is facilitated by a piece of ground glass held a little beyond the jet, so as to diffuse the light; or the *shadow* of the jet may be received on the ground glass, which is then held as close as possible on the side towards the observer.

If the jet be supplied from an insulated vessel, the coalescence of colliding drops continues for a time after the removal of the influencing body. This is a consequence of the electrification of the vessel. If the electrified body be held for a time pretty close to the jet, and be then gradually withdrawn, a point may be found where the rebound of colliding drops is re-established. A small motion *to* or *from* the jet, or a discharge of the vessel by contact of the finger, again induces coalescence.

Although in these experiments the charges on the colliding drops are undoubtedly of the same name, it appeared to me very improbable that the result of contact of two equal drops, situated in the open, could be effected by any strictly equal electrifica-

* Abstract of a Paper read before the Royal Society, March 13, 1879.

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tions. At the same time an opposite opinion makes the phenomena turn upon the very small *differences* of electrification due either to irregularities in the drops or to differences of situation, and is at first difficult of acceptance in view of the efficiency of such very feeble electric forces. Fortunately I am able to bring forward additional evidence bearing upon this point.

When two horizontal jets issue from neighbouring holes in a thin plate, they come into collision for a reason that I need not now stop to explain, and after contact they frequently rebound from one another without amalgamation. This observation, which I suppose must have been made before, allowed me to investigate the effect of a passage of electricity across two contiguous water surfaces. The jets that I employed were of about $\frac{1}{15}$ inch in diameter, and issued under a moderate pressure (5 or 6 inches) from a large stoneware vessel. Below the place of rebound, but above that of resolution into drops, was placed a piece of insulated tin plate in connexion with a length of gutta-percha-covered wire. The source of electricity was a very feebly excited electrophorous, whose cover was brought into contact with the free end of the insulated wire. When both jets played upon the tin plate, the contact of the electrified cover had no effect in determining the union, but when only one jet washed the plate, union instantly followed the communication of electricity, and this notwithstanding that the jets were already in communication through the vessel. The quantity of electricity required is so small that the cover would act three or even four times without being re-charged, although no precautions were taken to insulate the reservoir.

In subsequent experiments the colliding jets, about $\frac{8}{100}$ inch in diameter, issued horizontally from similar glass nozzles, formed by drawing out a piece of glass tubing and dividing it with a file at the narrowest part. One jet was supplied from the tap and the other from the stoneware bottle placed upon an insulating stool. The sensitiveness to electricity was extraordinary. A piece of rubbed gutta-percha brought near the insulated bottle at once determined the coalescence of the jets. The influencing body being held still, it was possible to cause the jets again to rebound from one another, and then a small motion of the influencing body *to* or *from* the bottle again induced coalescence, but a *lateral* motion without effect. If an insulated wire be in connection with the contents of the bottle, similar effects are produced when the electrified body is moved in the neighbourhood of the free end of the wire. With care it is possible to bring the electrified body into the neighbourhood of the free end of the wire so *slowly* that no effect is produced; a sudden movement of withdrawal will then usually determine the coalescence.

Hitherto statical electricity has been spoken of; but the electromotive force of even a single Grove cell is sufficient to produce these phenomena, though not with the same certainty. For this purpose one pole is connected through a contact key with the interior of the stoneware bottle, the other pole being to earth. If the fingers be slightly moistened, the body may be thrown into the circuit, apparently without diminution of effect. This, perhaps, ought not to surprise us, as in any case the electricity has to traverse several inches of a fine column of water. On the other hand, it appeared that most of the electromotive force of the Grove cell was necessary.

Further experiment showed that even the discharge of a condenser charged by a single Grove cell was sufficient to determine coalescence. Two condensers were used successively; one belonging to an inductorium by Ladd, the other made by Elliott Brothers, and marked "Capacity ½ Farad." Sometimes even the "residual charge" sufficed.

It must be understood that coalescence of the jets would sometimes occur in a capricious manner, without the action of electricity or other apparent cause. I have reason to believe that some, at any rate, of these irregularities depended upon a want of cleanness in the water. The addition to the water of a very small quantity of soap makes the rebound of the jets impossible.

The last observation led me to examine the behaviour of a fine vertical jet of slightly soapy water; and I found, as I had expected, that *no scattering took place*. Under these circumstances the approach of a moderately electrified body is without effect, but a more powerful influence scatters the drop as usual. The apparent coherence of a jet of water when the orifice is oiled was observed by Fuchs, and appears to have been always attributed to a diminution of adhesion between the jet and the walls of the orifice.

Some further details on this subject, and other investigations respecting the phenomena of jets, are reserved for another communication, which I hope soon to be able to present to the Royal Society; but I cannot close without indicating the probable application to meteorology of the facts already mentioned. It is obvious that the formation of rain must depend very materially upon the consequences of encounters between cloud particles. If encounters do not lead to contacts, or if contacts result in rebounds, the particles remain of the same size as before; but, if the issue be coalescence, the bigger drops must rapidly increase in size and be precipitated as rain. Now, from what has appeared above, we have every reason to suppose that the results of an encounter will be different according to the electrical condition of the particles, and we may thus anticipate an explanation of the remarkable but hitherto mysterious connection between rain and electrical manifestations.

EDISON'S ELECTRIC CANDLES.

The second invention in development of Mr. Edison's discoveries in connection with the use of electricity for lighting purposes has been patented in this country, and can be seen on payment of one shilling at the Great Seal Patent Office. This patent is entitled "Improvements in Lighting by Electricity." The final specification was filed on May 7, 1879, by Edward Griffith Brewer, of Chancery-lane, "acting on behalf of Thomas Alva Edison, of Menlo Park, State of New Jersey, U. S."

As set forth by the patentee in the specification, the special feature of the invention deals with the candle for the diffusion of the electric light. Mr. Edison's candle is in the form "such as a prism or cylinder," and is "a slightly tapering hollow cylinder, divided vertically except at the upper end." By this arrangement he claims that uniformity and complete incandescence are secured, as the electric current passes up one side of the candle and down the other. At the base of the cylinder, which is enlarged for that purpose, the electric conductors are connected. A "thermal circuit regulator," already described in the previous patent, is attached at the bottom of the candle, and so arranged that, if the current becomes excessive, the regulator becomes heated, and consequently expands, so as to bring a movable spring into contact with the adjusting screw of the illuminating apparatus, and thereby "short circuits" the current and lessens its action in the light. Mr. Edison proceeds to specify the materials of composition and the method of construction of the light-giving substance, of which the essential condition is necessarily the power to resist fusion by the great heat developed in the passage of the current. "Metals or oxides of metals are made use of, which produce, in a comparatively large candle, sufficient resistance to render the whole incandescent. Finely-divided metal or particles of metal having a high melting point are caused to adhere by earthy materials, such as magnesium or zircon oxides or magnetic oxide of iron, or other substances that are with difficulty fused. The oxides of metals may be obtained by chemical precipitation or otherwise, and the candle is moulded in either a dry or moist condition by pressure. The fine particles of metal may be platinum, iridium, ruthinum, or other metal that can only be melted at a high temperature; the earthy materials such as are unfusible, such as oxide of magnesia, *(sic)* zirconium, lime, silicum, boron, or other suitable material." Having thus enumerated the materials necessary for his invention, the patentee proceeds to detail the method of manufacture:—"In cases where these oxides or earthy materials are mixed with the fine metallic particles, such particles are thoroughly and uniformly mixed into a mass before it is moulded, and hence such particles are kept separate by the earthy material and cannot fuse or run together, and the metallic oxides themselves are electric conductors to a greater or less extent, and hence may in some instances be used without the particles of metal. In all cases the substances are moulded and pressed into shape under powerful pressure; and if the particles do not adhere together sufficiently, sugar, tar, silica, or similar material may be used in moulding the candles into shape, and these substances may be volatilised by the heat. The metallic particles are rendered highly incandescent, and the earthy substances or oxides also are rendered luminous by the passage of the electric current. In some instances the rods or prisms of oxides are saturated with the salt of a metal difficult of fusion, and this salt is reduced to a metallic state by heat, and the metal permeates the entire body in very minute particles, which are not liable to be melted and run together, in consequence of the intervening oxides or earthy matter." Finally, the patentee declares that his invention "is not limited to any particular form in which the candle may be moulded or otherwise shaped, but it relates to the materials employed in such candles, whereby the mass is adapted to the passage of the electric current; and it is rendered highly luminous or incandescent by such current." In his statement of claims appended to the specification of the invention Mr. Edison sets forth as follows:—"What is claimed as the invention secured by these letters-patent is that a candle or light-giving body for electric lights in which particles of metal or metallic oxide are moulded into a mass is adapted to the passage of the electric current and rendered luminous by the same, substantially as set forth." The specifications are accompanied by drawings illustrating the construction and regulation of the electric candle.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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ATLANTIC TELEGRAPHY.

We never yet met with any individual who at all times and under all circumstances persistently and consistently cried peace, peace. Our everyday life is a proof that, as things are now constituted, absolute peace is impossible, and is altogether absurd. Ordinary commercial competition is a kind of warfare, whether we call it such or not. The term "survival of the fittest," so often used in scientific nomenclature, is indicative of warfare. Wherever we go, the strife continues, and must continue. There is, however, a broadly-marked line of demarcation, beyond which the ordinary strife of the human family ends, and the fratricidal begins. The effort to increase one's wealth, or the financial condition of a firm, or to injure our neighbour can be carried on honourably only in certain well-defined lines. Actions beyond the pale must be resisted by extraordinary means.

Now, if all we hear is correct, there has lately been one of these unfair strivings carried on in telegraphic circles. As someone put it, the "*amour propre*" of the French nation has been injured by the fact that submarine telegraphy has been and is carried on almost entirely by Englishmen. We can hardly read such a statement in earnest, and yet this is given as a reason why a new company with a large capital should be floated to carry out a scheme of ocean cable enterprise which neither common sense nor commercial requirements warrant. What will be the result of carrying out such a scheme as the laying of two more Atlantic cables, and that, too, at a cost greatly in excess of the necessities of the case? Consider for a moment the present state of things. There are in existence two companies, the Anglo-American and the Direct United States, with cables across the Atlantic. The latter was originally formed in opposition to the former, and in the strife which of course arose, the Direct found itself unable to pay its way. The "war" was amicably settled, and since then both companies have rendered a return for the capital embarked in the enterprise. A third company is now raised solely and purely with the view to recommence the strife. There is, and there can be, no expectation of fairly earning a dividend. Every figure is against it. The shareholders of the existing companies have in this competitive warfare to look after themselves, and hence the first note of the struggle is sounded. At an extraordinary meeting of the Anglo-American Company last week, a resolution was confirmed, which is admittedly one of self-preservation. The resolution reads thus:—"That the Board of Directors be, and they are hereby authorised to make, execute, and carry into effect any contract or contracts, or other deeds or documents and do all other things which they may deem requisite or desirable for giving effect to the project set forth in the printed report of the directors to the proprietors, dated 31st March, 1879, and the memorandum annexed thereto, respectively submitted to this meeting, and either upon the terms stated in such report and memorandum or with such modification, if any, as the Board may approve, and for the purpose of the said project, and the protection of the Company's interest in France, to pay, apply, and invest any moneys of the Company as the Board may from time to time think fit." Such a resolution as this confers almost full powers to the directors of a company, and is evidently such as would be agreed to by shareholders only in exceptional occasions. It was in this case only after long and careful consideration, and a firm conviction that it was necessary that the powers were asked for and granted. What will be the result of this antagonism? We are informed that the new cable is being manufactured, so that it will be ready for laying in, say from twelve to eighteen months. Is there any reason which can be brought forward why the shares of this new Company will not, when thrown into the market, gravitate in value to those of the already paying companies? In our view of the case, this depreciation in value is certain, and simply involves the loss of a million sterling. This we have in previous articles endeavoured to show—but the great question remains to be answered—Who will lose this money? It is hardly to be expected that the promoters will act so

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incautiously as to harm themselves, and thus we are forced to the conclusion that the most energetic of the founders have provided for cases of accident, and that whatever happens in the war of tariffs that may arise, the originators of the scheme will be found to have followed the soundest advice ever given, viz., to provide for the welfare of the greatest number, the greatest number being number one. It is not the ordinary competition of business to enter upon a scheme involving so large a capital without showing that there is an average prospect of success. The great anxiety shown not to make public aught that concerns the scheme ought to be sufficient to warn aside all English capitalists.

CORRESPONDENCE.

THE CAPACITY OF A SPHERE IN SPACE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Dr. Lodge does not appear to have read my note under this heading (p. 283) which he professes to answer. I there fully admitted that the capacity of a sphere varies approximately as its radius when the sphere is enclosed within a conducting shell connected to one of the poles of the charging source, and when the distance between the two opposing surfaces is much greater than the radius of the enclosed sphere. But I pointed out that this law, which is applicable when one of the opposing surfaces increases, approximately, as the square of the distance between the surfaces, and thus becomes infinitely great when the distance is infinite, cannot be applicable, generally, to the case of a "sphere in space," unless it be assumed that such sphere is necessarily enclosed, virtually or actually, within a conductor. Nor can it be applicable when the opposed surfaces are of equal area, and when these surfaces remain constant whatever may be the distance between them. In such case, if the path of inductive propagation were prismatic, it is quite clear that the charging capacity would be *nil* when the distance between the surfaces became infinite. But the path of propagation would *not* be prismatic, *i.e.*, the lines of force would not for the most part be straight, but curved, and would pass in every direction between the opposed surfaces, as in the case of the lines of electrolytic polarisation between "earth-plates" at great distances apart. Therefore I admit that equal opposed surfaces at a vast distance apart in a "boundless dielectric" may have a charging capacity. The questions of interest are (1): what would be this capacity in any given case? and (2) how would this capacity vary—in the case, for instance, of equal spheres or flat plates—when the diameters of the spheres or the areas of the plates are varied? These questions are not answered by stating that the capacities of spheres, the surfaces of which are "opposed" to the interior surface of a moderately large room, would vary approximately as the radii of the spheres.—Yours, &c.,

DESMOND G. FITZGERALD.

THE ENERGY STORED UP IN AN ELECTROSTATIC CHARGE.

TO THE EDITOR OF THE ELECTRICIAN.

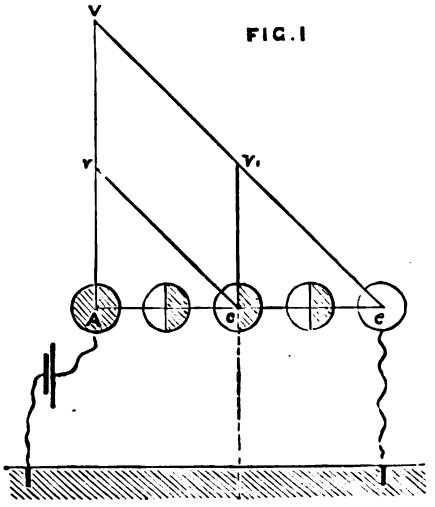
SIR: I have to object, *en passant*, to the second paragraph of Dr. Lodge's last letter under this heading. The imputation of disingenuousness is decidedly "bad form," and the *ex cathedrâ* decision upon a point yet under discussion is at least premature. Still, Dr. Lodge is, generally, a courteous as well as an able antagonist; and, now that I have said my word of protest, I have done with this matter. I would, however, pray my adversary to write me as one of whom Schiller says "he loves truth better than his system, and will gladly give up her old and defective form for a new and fairer one."

I am not sure that I quite understand the postulate at the commencement of the fourth paragraph of the letter in question. In the given connection, I should take the word "point" in its popular signification of "an indefinitely small portion," as in the statement:—"all points of an external surface may become charged." It would, no doubt, be absurd to speak of a mathematical point as having a charge.

But it is in the fifth paragraph that I find the main gist of Dr. Lodge's letter. In his view, the molecules of a polarised dielectric have no charge of free electricity; and thus, when an electrometer is charged from a wire, pointed or tipped with flame, immersed in such dielectric, the charge is "really obtained from the surface of conductors in the neighbourhood." Herein, I imagine, is one of our chief points of difference. In my view, the molecules of a polarised dielectric are perfectly analogous to minute polarised conductors, except that the former are insulated from each other only by intermolecular space or "ether." Thus the molcules of a dielectric, as well as isolated conducting masses, would, when polarised, have a free inducteous charge, which would be communicated to conductors brought into contact with them. Considering the enormous conductive resistance of dry air, how otherwise could we explain the effect of a flame-tipped wire in charging an electrometer when the flame is at a very considerable distance, horizontally, from a charged conductor?

But without, for the present, appealing to the direct results of experiment, I will, with your permission, briefly illustrate my view by means of diagrams. Let A (fig. 1) be a conductor charged directly from the pole of a source, *s*; let a similar conductor, *e*, and also the opposite pole of the source, be connected to earth; and let *c*, &c., represent intermediate similar conductors insulated from each other and from earth. Or, rather, let A represent a *particle*, or, if we may use the term, a *point* in a conductor obtaining an inductric charge; let *e* represent a corresponding particle in a similar conductor connected to earth and obtaining an induced charge; and let *c*, &c., represent *either* intermediate particles of conducting matter, or intermediate molecules of dielectric. What I maintain is that the latter will be polarised in precisely the same manner as the former; an inducteous charge of free electricity being obtained, in either case, by the particles.

FIG. 1



Let the tension-difference (or potential-difference) of the source be $E = A\ V = 4$. Then, if the resistance of the source be neglegible, the tension or potential at *c* will be $c\ v_1 = e = 2$, whether *c* be regarded as being a particle of conducting matter or a particle of dielectric. Thus I should say that the potential of the *point c*, or of the equipotential *surface* to which the particle *c* might belong, was $e = 2$.

Let us now take the intermediate particles to represent molecules of dielectric. Then let the inductive resistance of the circuit formed through these molecules be $R = A\ e = 4$. The quantity accumulated in this circuit—that is to say passing from one pole of the source to A, propagated inductively to *e*, and completing the circuit through earth to the other pole of the source—will thus be $Q = \frac{E}{R} = 1$. And (neglecting, as we have done, the branch circuits which would be formed) the *plus* charge of A would equal the *minus* charge of *e*. And further, according to my view, the inducteous charge of *c*, and that of each of the intermediate dielectric particles, would be equal in quantity to the charge of A and, of course, of the same sign.

Now the question—to my mind a very interesting one—is what would happen if the particle of dielectric *c* were connected to earth (or to a conductor in proximity to "earth"), say by means of a pointed wire? The question appears at first to be necessarily complicated by the effect on the circuit of this conductor. But it is found that, if our pointed wire be attached to an electrometer, the instrument will obtain, not merely a temporary charge due to the polarisation of the wire, but a charge which is permanent when this conductor is removed from its proximity to *c*. This charge is of the same sign as that of A; and Dr. Lodge, in common with many other electricians, would probably contend that it is simply derived from this conductor. This view receives *primâ facie* confirmation from the fact that the potential at A will fall when the charge in question is accumulated, or

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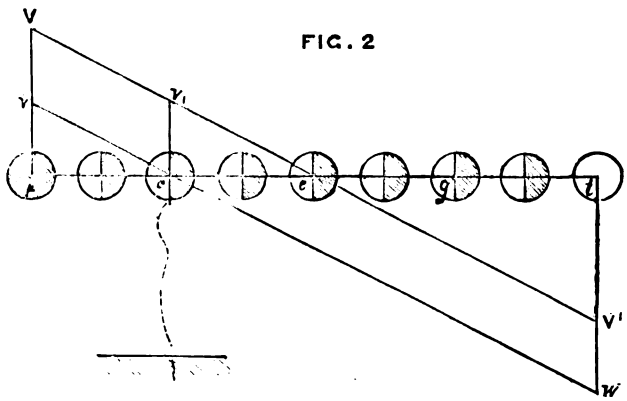
led to earth. What I venture to maintain, in opposition to this view, is that the quantity accumulated upon A is not diminished when the electrometer is charged through the wire in contact with c, and that the charge of the instrument is derived from this polarised particle of dielectric—in fact that what happens is precisely what would occur if c and the other intermediate particles were polarised *conductors*.

Now supposing our polarised particle c of dielectric thus to lose its inducteous charge, the quantity Q would, under the conditions above-mentioned, pass to earth, and the resistance of our inductive circuit would now be $r = A\,c = 2$; the potential at A would be $v = Q\,r = 2$; and the energy stored up in the charge (Q) upon A would be $\frac{1}{2}\,Q\,v = 1$. But the original energy of the charge was $W = \frac{1}{2}\,Q\,E = 2$; and the difference between these two values represents the work w done by the passage to earth of the inducteous charge upon c. Thus we have, as the value of the original potential at the point c,

$$e = \frac{2\,w}{Q} = 2.$$

When, however, as under the conditions represented by fig. 2,

FIG. 2



the resistance of the circuit is not *reduced* by connecting to earth a polarised particle or equipotential surface, then the evidence in favour of the view held by Dr. Lodge is, apparently, greatly strengthened, and the *primâ facie* difficulties in the way of accepting my conclusions that *the tension or potential of a point or* (equipotential) *surface is simply that of the static charge accumulated at this point or surface*, and that this tension or potential is in every case expressed by $V = \frac{2\,W}{Q}$, are correspondingly increased. But, with your permission, I will defer until next week the conclusion of my answer to Dr. Lodge's letter.—Yours, &c.,

DESMOND G. FITZGERALD.

THE CONTACT THEORY OF VOLTAIC ACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The paper by Messrs. Ayrton and Perry is interesting and shows a great deal of industrious work for science. But it is a question if the results are not to be arrived at by very much more simple processes, and whether the object sought, viz., the difference of potentials between two substances, solid or liquid, is not a delusion, or at all events whether that mode of stating the phenomena is not the expression of a preconceived theory rather than of facts. I have done a good deal of work in the same direction, though only part of my results have been published. They are embodied in the chapter on electromotive force in my work "Electricity; Its Theory, Sources, and Applications." But I found that this so-called contact potential, is simply the intensity of chemical affinity, proportionate to the energy such action can generate as heat. This agrees with the experiments referred to by Clerk Maxwell lately, which show that the contact potential of copper and zinc, instead of being what is often stated, is almost inappreciable; doubtless it is just proportionate to their natural tendency to unite as an alloy. The same principles show us why substances and liquids at different temperatures develop this so-called contact potential: it is due simply to the transfer of energy from one to the other. Sulphuric acid in contact with water, &c., develops high potential as the authors say, just because the acid in the act of combining with water sets free great heat, which under the proper conditions takes the form of an electromotive force which transmits that heat, or energy set free, elsewhere in the circuit, which circuit is the essential element of this development of contact force, or whatever we may choose to call it. Any action whatever which can produce a molecular disturbance will, if properly directed, give us corresponding results.—Yours, &c.,

J. T. SPRAGUE.

POTENTIAL AND INFINITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. FitzGerald and Dr. Lodge run a tilt at me from opposite sides on pages 296-7. Imperative calls upon my time just now compel me to postpone the encounter, and leave them to continue their charges against each other. I will return to the subject of Mr. FitzGerald's objections, only saying now that I am aware that I have not put my case as fully and clearly as it should be made out. I have omitted to notice, in expressing Electromotive Force as $\sqrt{\text{energy}}$, that this is true in unit conditions, and in equal resistances, but that in many cases this energy is not used up. Part of it remains as potential energy in the source, just as with head of water.

As to Dr. Lodge's remarks, I am perfectly content to be called a paradoxist but object to be classed among circle-squarers. A paradoxist is simply a man who thinks for himself instead of running in the groove cut out by others. He may be right or he may be wrong in his thoughts, and it remains to be proved yet that my paradoxy is not simply that of any reformer. But circle-squarers are mathematicians who waste their energies upon insoluble problems or on problems not worth the solving, and in that class I do not think my remarks place me. At all events I must ask Dr. Lodge to answer my question. If charge involves two surfaces and a dilectric, the surfaces being electrodes connected to a source and conveying energy from that source to the dielectric, how are we to conceive the opposing surface, the source, and the dielectric concerned in putting a charge upon a sphere isolated in space? I must confess to great surprise at his admitting that these are really the conditions of charge; if mathematicians generally are prepared to do so, they are leaving their old ground and coming over to the very doctrines which we paradoxists have been teaching them for some years past. They will have to give up Potential of a surface or point, or difference of potential between two surfaces, recognise that these are simply expressions of the energy charged upon a definite field of force, and throw "infinity" into the waste basket of science.—Yours, &c.,

J. T. SPRAGUE.

THE CONTACT THEORY OF VOLTAIC ACTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The revival of this subject by Professors Ayrton and Perry renders it very desirable that the original papers be reprinted in the columns of *The Electrician*. To many of your readers the paper, an abstract of which appears in your issue of the 10th inst., would be unintelligible, seeing that the accounts of the earlier researches by Ayrton and Perry must have had a very limited publicity. They appear in the published proceedings of the Royal Society for 1876 and 1877 I think; and their reproduction in your Journal would be of great service.—Yours, &c.,

May 13, 1879. M. F.

THE SUPPLY OF ELECTRICITY FOR PRIVATE USE.

BY E. HOSPITALIER.

(Translation.)

The problem of the distribution of electricity to private houses, &c., the solution of which, ten years ago, would have appeared almost impossible of realisation, is one which, at the present moment occupies many practical and enterprising minds both in England and France. This problem may briefly be considered under the following headings:—

1. The production of electricity.
2. The means of supplying it to private establishments.
3. The division and distribution of the current.
4. The application of the current for various domestic, scientific and industrial purposes.

1. *The Production of Electricity.*—In the first place we may assume that the use of any of the voltaic batteries at present known is out of the question, by reason of their expense and inconvenience. Convenience and economy both point to the employment for the generation of the electrical supply of dynamo-electric or magneto-electric machines, worked by steam engines of great power. A true manufactory of electricity, established in the centre of a given district, might supply this district much in the same way as a gas works generates gas to be distributed in all directions. The construction of the magneto-machine must depend in some measure upon the conditions under which the electricity is to be utilised. The requirements are that such a machine should generate a continuous and constant supply, and that this supply should be the maximum obtainable

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with a given consumption of fuel. At the present moment the Brush, Siemens, Wallace, Lontin, and Gramme machines realise to a great extent these requirements. The further improvement of these machines must render the problem more practicable by diminishing the cost price of any given unit of electrical supply.

2. *Conductors for Supplying the Electricity.*—Whichever of the above generators of electricity may be adopted, it will be capable of furnishing powerful currents of electricity, which will have to be conducted away to the localities where they may be utilised. The conducting wires, which should be of copper, might either be insulated in air by means of the glass or porcelain insulators employed upon overland lines, or be covered with a solid insulating material such as gutta-percha, preferably with the addition of a sheathing of lead. In the latter case, they might be laid along the sewers, or in stoneware pipes beneath the surface of the streets or roads. For comparatively short distances, this portion of the problem would appear to present no serious difficulty.

3. *Division and Distribution of the Electric Current.*—We here come to the most delicate part of the question—one, however, in which recent solutions have rendered practicable the distribution of electricity for private requirements. It is not sufficient to have brought the electrical supply to the consumer, we must further enable him to subdivide it into any required number of equal or unequal parts; so that each partial current may be proportioned to the effect it is intended to produce. The appliances by means of which this condition is realised are termed automatic current-regulators, and are based on the two following principles:—

1. The intensity of the current in a given circuit depends upon the resistance of this circuit; and, according to Ohm's law, the current will, other things being equal, be inversely as the resistance. Thus a current proceeding from any source may be diminished to any required extent provided we introduce in the circuit a sufficient resistance.

2. When several derivations are established in a voltaic circuit, the intensity of the current in each of these derivations will depend upon their several resistances.

In accordance with the latter principle, we may obtain in any derivation the current most suitable for the apparatus or purpose for which it is established.

The function of an automatic regulator of the current is to produce variations in the resistance by means of those variations which tend to become produced in the current itself; the apparatus thus constitutes a true *electric tap*, the use of which is indispensable whenever any considerable variation in the current may be of detriment. The form given to the apparatus may be indefinitely varied; but each regulator hitherto devised is possessed of special properties which should determine the selection to be made in any given case. Dr. Siemens utilises the variation in length of a metallic wire, according to the greater or less degree of temperature produced in it, for the insertion of a greater or less resistance in the circuit. Others utilise the variation in the strength of an electro-magnet, by means of which, again, the resistance in the circuit may be suitably augmented or diminished.

System of Charges: Electric Meters.—Whatever may be the purpose for which the electric supply is required, some system of charging for it has to be devised. According to circumstances, either of the three following methods may be adopted:—

1. To charge the consumer so much per *diem* and per unit of quantity or per Weber of electricity laid on, whether this be actually utilised or not. This system is already adopted for water supply and in letting out steam power. It is the simplest and the most practical system whenever the consumption is tolerably regular.

2. To insert a voltameter, in a derivation of high resistance, from the current supplying each consumer, and to measure the supply by means of the gas evolved in this apparatus. This idea, suggested by Professor Hughes, is quite practicable when a tolerably exact measure of the electricity supplied is requisite.

3. To utilise the regulator established on the premises of the consumer, for the purpose of recording, upon a band of paper moved by clockwork, the consumption of electricity from time to time.

We have now to consider the application of the currents of various intensity which, by the use of a suitable regulator, may be obtained in the derivations established from the main conductors proceeding from our source of electrical supply.

4. *Applications of the electric current.—Electric Lighting.*—The lamps recently devised by MM. Regnier, Werderman, Ducrétet &c., or the incandescence lamp with a coil of the platinum-iridium alloy, might be employed for this purpose. The main question involved in this application is simply that of sufficiently reducing the cost of the electrical supply. It must however be admitted that, whilst this application is the one which possesses the greatest importance in the future, it is also that which necessitates the greatest amount of labour in order to render it perfectly practicable.

Motive power to be supplied to private houses, &c.—Here electricity is capable of effecting an easy triumph; for the electric motor, under the special conditions provided, affords a practical and elegant solution of many requirements. This motor, considered exclusively as a motor, is an almost perfect machine which, after having been much praised, has been unduly condemned by reason of the difficulty and expense of maintaining the batteries which, until recently, have alone been available for working it. The aspect of the question becomes completely changed when the latter is considered in connection with the proposed distribution of electricity. According to experiments which have been made, a horse-power may be utilised on the premises of the consumer by the expenditure of but little over two horse-power at the manufactory whence the power is distributed—an expenditure which is insignificant when it is considered that the steam engine at the manufactory would be one of great power, which would not consume more than one kilogramme of coal per hour and per horse-power. For we have to consider also the wonderful simplicity and adaptability of the electric-motor, consuming nothing in waste, and always ready to be set in action by the mere movement of a commutator. Many ways of utilising it would no doubt speedily be found: we may in this connection mention the sewing machine, the turning-lathe, machines for sawing, &c., knife-cleaning and washing machines, the bellows of organs, the mechanical piano, the printing press, the curtain and movable scenery of theatres, the revolving shutters of shops, &c.

Let us also mention, amongst the other modes of utilising the electric supply, the contrivance of the safest means for obtaining a light, and small sources of heat, the lighting of gas by the action of turning it on, alarums giving warning of fire or thieves, electric bells and electric clocks. Then amongst special applications we have electrotyping, gilding, silvering and nickel deposition, and the temporary production of a vivid light for the purposes of the photographer.

We may, I think, conclude that all these applications, and doubtless many others, will be largely adopted when those who can turn them to practical account are no longer under the necessity of giving their attention to the main point:—*the production of the electricity.*

THE CAPE AND SOUTH AFRICAN AND AUSTRALIAN DUPLICATE SUBMARINE TELEGRAPH CABLES.

On Tuesday, May 13th, a party of ladies and gentlemen accepted the invitation of the Telegraph Construction and Maintenance and Eastern Telegraph Companies to witness the shipping of the Delagoa Bay and Mozambique section of the Cape Cable, and the manufacture of the cable for the other sections of this line, and also for the duplication of the Australian Submarine Telegraph Cables between Penang and Port Darwin.

A special steamer conveyed the guests from Westminster to the Telegraph Construction and Maintenance Company's steamship Seine, lying off their works at East Greenwich. Previous to luncheon, which was served on board the Seine, the coiling of the cable into the ship and the apparatus for paying out and picking up were inspected. The factories were afterwards visited, and the different processes of manufacture examined, one of the most interesting and striking features being the armouring of the cable to resist the attacks of the teredo and other marine insects.

The company finally embarked on board the steamer which had brought them down, and returned to Westminster after an enjoyable day.

Amongst the visitors were Sir Michael Hicks-Beach, Bart., M.P.; Lord Cadogan, Sir H. Selwin-Ibbetson, Bart., M.P.; Admiral Sir James Elphinstone, Bart., M.P.; Sir Daniel Gooch, Bart., M.P. (Chairman of the Telegraph Construction and Maintenance Company); Mr. John Pender, M.P. (Chairman of the Eastern Telegraph Company); Sir Erskine May, Lord Arthur Russell, M.P.; Lord Alfred Paget, Sir Thomas Fairbairn, Bart.; Vice-Admiral Sir G. H. Richards, C.B., F.R.S.; the Right Hon. Mr. Hugh Childers, M.P.; Mr. W. C. Sargeaunt, Mr. R. G. W. Herbert, Mr. C. W. Stronge, Sir James Anderson, General Maclagan, Professor Pearson, Mr. Goldney, M.P.; Colonel Channer, R.E.; Mr. C. W. Earle, Mr. F. Bevan, Mr. P. Rawson, Mr. G. W. Campbell, &c., &c.

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THE EXHIBITION OF ELECTRIC LIGHT APPARATUS AT THE ALBERT HALL.

The Albert Hall is perhaps not so well known as it might be. The building is not of an ordinary character, nor is it useful for ordinary meetings. It is, however, admirably adapted for showing the good and the bad points of the electric light, and thus was suited for an exhibition of electric light apparatus which included many machines and lamps actually in working order. Mr. Preece in his inaugural lecture, truly said that the exhibition was as unique as it was comprehensive. All the best known lamps and machines were exhibited.

It will not be necessary for us to describe in detail the apparatus exhibited, as we have already in our columns described and illustrated most of what was shown; and shall take the earliest opportunities of referring to the few things not hitherto mentioned. The exhibition consisted of the following:

WORKING EXHIBITS.

West Arena Entrance.—Otto gas engine, 8 h.-p. driving, exhibited by Crossley Bros.; electric machine 2 Gramme "A," by British Electric Light Co.

East Arena, Covered Entrance.—Two Marshall's portable steam engines, driving four Gramme "A" machines, lighting approach to Hall, by India Rubber, &c., Co.; one Wallis and Steevens portable steam-engine, driving Wallace-Farmer machine, by Anglo-American Electric Light Co.; Gramme "D" with "Brotherhood" three-cylinder engine, complete on frame, by the War Office.

Engine-room: Electric Machines.—Siemens single light, by Siemens Bros.; Gramme multiple light, by the Société Générale d'Electricité; Lontin multiple light, by G. P. Harding; Wilde multiple light, by the Electric Lighting Co.

In *Arena of Hall* are the following working exhibits:—*Electric Lights.*—Siemens, by Siemens Bros.; Serrin, Werdermann, Reynier, and Higgins, by British Electric Light Company; Rapieff, by National Electric Light Corporation; Wallace, by Anglo-American Electric Light Company; Iridium incandescent light, by Anglo-American Electric Light Company; Jablochkoff, by Société Générale d'Electricité; De Meritens, by Edmundson and Co.; Wilde, by the Electric Lighting Co.

ILLUSTRATIVE EXHIBITS IN ARENA OF HALL.

Otto gas-engine, 3½ h.p. driving, by Crossley Bros.

Gramme machine and Werdermann lamp.

Electric Machines:—Saxton, by Royal Institution; Holmes (original magneto-electric machine), by Trinity House; Alliance Co. (magneto-electric machine), by Trinity House; Holmes (original dynamo-electric machine), by Trinity House; Gramme (magneto), by Ladd; Gramme dynamo "M" size, by India Rubber and Gutta Percha Co.; Wilde's magneto, by Royal Institution; Siemens (original dynamo-machine, shown before Royal Society), by Siemens; Ladd (double armature) dynamo, by Ladd; Siemens (single-light) dynamo, by Siemens Bros.; Siemens (dividing-light) dynamo, by Siemens Bros.; Gramme (quantity-working Werdermann) dynamo, by British Electric Light Co.; Gramme (dividing-light), by Edmundson and Co.; De Meritens (small machine) magneto, by De Meritens; Schuckert dynamo, by B. Brain; Wallace-Farmer, by Anglo-American Electric Light Company; Tisley's dynamo-electric, by S. C. Tisley and Co.; Wilde's electro-magnetic inductine, by The Electric Lighting Company.

Electric Lamps.—Regulators: Siemens (small size and light-house), by Siemens Bros.; Duboscq, by Trinity House; Holmes (original and improved), by Trinity House; Chapman, by H. Chapman; Serrin and Suisse (Hallé), by the British Electric Light Company; Serrin-Suisse (*a* ordinary form, *b* for sixteen hours burning, *c* large marine size), by F. Suisse; Rapieff (four and three-carbon forms and "Moderator"), by the National Electric Light Corporation; Serrin-Lontin, de Mersanne, by G. P. Harding; Wallace, Jasper, and others, by the Anglo-American Electric Light Company; Hand and inclined of different kinds, by the War Office; Krupp, by B. Brain; Pyramid, by B. Brain; and De Fonvielle, by W. de Fonvielle.—Candles: Jablochkoff, by the Société Générale d'Electricité; Wilde, by the Electric Lighting Company; De Meritens, by De Meritens; Rapieff, by the National Electric Light Corporation; and André, by G. G. André.—Incandescent Lamps: Reynier, by W. Crooks; Werdermann, by the British Electric Light Company; Higgins, by Leslie C. Hill; Iridium Light, by the Anglo-American Electric Light Company; and Mining, by G. G. André.

Carbons.—Samples of manufactures of by Carré; Sautter, Lemonier, and Co.; Siemens; India Rubber and Gutta Percha Company.

Photometric Apparatus.—Photometers, and 6-wick colza oil Trinity lamp, by Trinity House; Bunsen photometer, and 16-candle sperm-oil lamp, by T. W. Keates; Bunsen photometers, lamps, and standard sperm candles, by W. Sugg; and Wheatstone photometer, by British Electric Light Company.

Other Apparatus.—Holophote, by War Office; Lighthouse dioptric apparatus, by Trinity House; projector, by Siemens Brothers; Harding's velocimeter, by Siemens Brothers; velocimeter, by R. Applegarth; instruments adapted to the use of the electric light in surgical operations, by G. Trouvé; hand-lamp for use in surgical operations, by B. Squire; bracket-lamp for use in dental operations, by B. Squire; Grieve's lantern shade or theatrical "medium," by J. J. Calder; and Obach's galvanometer, by Siemens Brothers.

Conducting Wires and Cables.—Samples of different kinds used for electric lighting, by Siemens Brothers; British Electric Light Company; G. P. Harding (Lontin lights); Société Générale d'Electricité (Jablochkoff candles); and India Rubber and Gutta Percha Company.

WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).

The fourth ordinary general meeting of the shareholders of this Company was held on Wednesday, May 14, at the Cannon Street Terminus Hotel, Mr. C. W. Earle, the Chairman, presiding.

Mr. C. M. HOOPER, the secretary, having read the advertisement convening the meeting, the report of the directors for the half year ending the 31st of December last was taken as read. It stated, *inter alia*, that the amount to credit of revenue was £37,052 12s. 9d., and the expenses had been £24,449 9s. 4d., leaving a balance of £12,603 3s. 5d., which, with the balance £3,391 7s. 6d. brought from last account, made an available total of £15,994 10s. 11d., with which it was proposed to deal as follows:—A half year's dividend to 31st December, 1378, on the first preference shares, at 6 per cent. per annum, absorbing £10,368 18s.; a similar dividend on the second preference shares, £1,400 14s.; to reserve account, £2,000; balance to current half year's account, £2,224 18s. 11d. The receipts from messages for the past six months had been £1,680 in excess of those for the corresponding period of 1877, and there was an increase of £500 received on account of an additional subsidy, making together a total increase of £2,180. As against this, however, the arrears of the St. Vincent subsidy, amounting to £2,600, were received in the corresponding period, and, consequently, a comparative falling off was shown in the total receipts of £420. The expenses over which the directors could exercise control exhibited a small reduction, but the item of repairs to cables on account of accidents had been exceptionally heavy.

The CHAIRMAN, in moving the adoption of the report, reminded the shareholders that when they met last time he had to tell them a history of rather shortened traffic receipts, but a very small expenditure on account of cable repairs. This time in those respects the story was reversed, because they had had an improvement in their traffics, but a very serious increase in the expenditure on cable repairs. It must be evident to them all that that was a matter entirely out of the power of the directors to control. The wind and waves were violent in the West Indies. Their cables in some instances in part of their course lay over coral reefs, and the sea washed them about; and very frequently, he was sorry to say, caused interruptions, which had to be repaired. Generally, he believed, they had about six of these interruptions in the course of a half year, but in the past six months there had been nine; and three or four of them "walked away" with the sum necessary to pay a dividend on the ordinary shares. This was a risk and a danger which every cable company was exposed to; but the great difference between this Company and other cable companies was that they had a revenue—most of them—sufficient to meet all these risks, and give a moderate dividend to the shareholders; but in the case of this Company—and the matter was put as clearly as it possibly could be in the fourth paragraph of their report—their receipts, including those from every source, were only £19 per mile as against £39, the average of the dividend-paying ocean cable companies. They might understand how differently they would be placed if they had that extra £20 per mile, for they would be able to maintain their cables, execute their repairs, renew and keep up their system, and give them the dividend they ought to get on a business of this sort. He thought it was very essential that they should all, according to their means and influence, endeavour to impress on the colonies and every one connected with them, how very inadequately this enterprise was supported; and, in alluding to this point, he would like to make a few remarks about what was stated by one of the shareholders as to the view he took at their last meeting about the Company's affairs—he referred to Mr. Abbott, who on that occasion remarked that he (the Chairman) was "laying on the black paint too thick" [laughter]. He thought that he was perfectly justified in "laying on the black paint" as he did [hear, hear]; but the evil of such a remark as that of Mr. Abbott was not on this side, but in the fact that it was taken up in the West Indies, where it was said that the shareholders of the Company did not agree with the Chairman having observed that he was "laying on the black paint" in dealing with the Company's affairs [hear, hear]. He knew that Mr. Abbott's remark was friendly and good-natured, but still it would have that effect in the colonies, where it was taken up, and where there appeared in the papers remarks adverse to the claims and demands of the Company on them for greater support. Another argument which was greatly favoured in the colonies was against the increase of rates which the Company had established. They said that the increase of rates had not benefited the Company, and, for this reason, the directors had introduced the fifth paragraph in their report. From that the shareholders would observe that the traffic receipts, &c., after deducting the cost of the news supplied to the colonies, amounted to £48,000 in 1876, while they rose to £61,000 in the two subsequent years [hear, hear]. Therefore, although the total revenue was very inadequate, still the policy of increasing the rates had so far answered their purpose that it had given them some £12,000 a year beyond what they earned before in their best days. The grant of £2,000 a year from Jamaica was

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a very satisfactory item in their somewhat unfortunate position. It was a more satisfactory item coming after the cables were laid than if it had been done as one of the conditions upon which the cables were to be laid, because it recognised the services of the Company and the necessity of further encouragement; and he hoped that the example thus set by Jamaica would be followed by the other colonies, who from their situation required a greater length of their cable to keep up their communications, and therefore ought in future, he thought, to grant them a larger subsidy, and a proportionately greater subsidy for the greater distance of the commencement of their line. Jamaica was only 120 miles from the terminus of their line, whereas Demerara, Barbadoes, and some other places were about 3,000 miles; and therefore the Company's claim on them was greater than it was in the case of Jamaica. They had had to deplore the accident to the Investigator, and they all regretted that it should have resulted in the deaths of two men in their service. In regard to their claim on the underwriters, and their liability to the Company, the matter was in the hands of the lawyers, and he thought it would not be judicious further to allude to it. As to the accounts, the liquidation was not yet concluded, as one of the concessions was not yet transferred, but the accounts, so far as they affected the liquidation, appeared in the balance-sheet. He then moved a resolution for the adoption of the report, and the declaration of the dividends recommended payable on and after the 15th inst.

Mr. WEAVER having formally seconded the motion,

Mr. FORWARD asked whether all the Colonies paid the subsidy they agreed to. He thought the receipts for messages should be separated from those derived from subsidies. He also desired to know whether any great increase in the subsidies was to be expected.

Mr. NEWTON asked what progress was being made with respect to the South American cable, a matter as to which he thought there had been some neglect. He was convinced that the carrying out of this project would have a most important bearing on the revenue of the Company. Was the local traffic increasing?

The CHAIRMAN, in reply, to these and other questions, said the increase of the rates had benefited them to the extent he had mentioned, and as shown in the fifth paragraph of the report. The number of messages transmitted had decreased, as might almost have been expected with the increase in the rate charged, but on the whole the increase had been advantageous to them. The subsidies received were all in the accounts; but as to separating subsidies from receipts, there were important reasons why this change should not be made in their accounts, and he hoped that the matter would not be pressed. They had paid off some of the six per cent. debentures, and when the seven per cent. debentures fell in they would do what they could; but this depended on the state of their funds. These debentures would expire next year. As to any hope of increased subsidies, they were for certain terms, at the end of which they must go to the colonies and press them to give the Company more. They had repeatedly shown that their traffic was not sufficient for their system. He should hope when they went to the colonies at the end of the term that they would increase the subsidies they gave, if they wished communications to be kept up. As to the South American cable, they had proposed from time to time to enter into negotiations for the resuscitation of the cable, but at present the proprietors did not see their way to join the Company in the matter. He hoped that their views or their position might change, but they had no control in this matter, as the cable was not theirs. Their local traffic, he believed, remained about the same—he did not think there was much variation from year to year.

Mr. ABBOTT thought that the information wanted as to the subsidies was if all the colonies who were at present enjoying the advantage of telegraphic communication were contributing a subsidy to the Company—if every one of the West Indian colonies contributed its quota towards the expenses of the Company. He could quite agree with the Chairman that it would be impolitic to publish what each colony paid them, more particularly as the local press were very active in their opposition, notwithstanding the benefits conferred on them by the Company. Was the Investigator now undergoing repairs?

Mr. SUTTON wished the Chairman to give the meeting any information he might possess relative to the application made some time ago to the Home Government.

Mr. VEARS spoke warmly of the claims of the ordinary shareholders to some consideration, and complained that they had been "left out in the cold." He thought that some small dividend might be paid to them in view of the fact that it was proposed to transfer £2,000 to the reserve fund, and to carry a balance of £2.224 to the next account.

Mr. ELEY spoke of the importance of adding to the reserve fund. They had a capital of £1,200.000, and only £2.300 reserve fund.

Mr. NETTLESHIP thought directors' remuneration was too much—2½ per cent. on the gross, and 8 per cent on the net receipts.

Mr. ABBOTT, on the other hand, contended that the directors ought to be paid according to the value of their services, and he referred to what the present Board had done since they entered office.

The CHAIRMAN, in further reply, said: With regard to their application to the Home Government, the matter was in the hands of the Treasury, and they thought that while it was there there was some hope of a favourable reply. All the colonies which agreed to subsidise the Company were paying them, and they had the Jamaica subsidy in addition to the original list. Every other colony paid them, except the Spanish colony, to whom they had applied over and over again, but ineffectually. As to the remarks of Mr. Vears, he agreed with the other shareholder, and regretted that the reserve fund was not larger [hear, hear]. They had a depreciating property—all property such as theirs was of a depreciating character, and if they did not write off something periodically he did not know where they would be at the end of the time when the property ceased to be valuable. Nothing could give the directors greater pleasure than to be able to divide the reserve fund, but it would not be safe to do so. They had 4,000 miles of cables, and he thought that they put by very little to meet the depreciation, which was not a risk, but a certainty. As to the Investigator, they were trying to get the matter settled as soon as possible. Mr. Newton had charged them with neglect as to the cable to which he had alluded, but the directors really had no control in the matter—they had done all in their power in approaching the owners of that property with the view of resuscitating it. He should be delighted to see it re-opened.

Mr. ABBOTT asked what it would cost to lay another cable.

Mr. FORD: Three-quarters of a million at least.

The CHAIRMAN then put the resolution, which was carried unanimously.

Sir JAMES ANDERSON next moved the re-election of Mr. Earle, who, he said, was one of the most assiduous chairmen he had ever known, leaving nothing uncared for. All the matters discussed to-day were thoroughly discussed at their Board meetings, and he could only say that the shareholders' interests were not neglected.

Mr. ANDREWS seconded the motion, and it was carried unanimously.

The CHAIRMAN, in reply, expressed his thanks, and said he would always do his best, but it was very uphill work trying to earn a dividend in so poor a field as the West Indies.—He then moved the re-election of Mr. Ford, and the motion having been seconded,

Mr. FORD expressed his surprise to hear Mr. Newton charge the Board with neglect in the matter of the cable referred to. If he had inquired at the Company's office Mr. Newton would have found that the Board had given that matter their most careful consideration; but in the financial position of this Company, and in the position in which the associated company—the Western and Brazilian Telegraph Company—was placed, this Board found that neither company was able to incur the very large expenditure which would be necessary to undertake the preliminary experiment of raising the cable. Such an experiment would be done at the cost of the preference shareholders, and they must remember the pledge which was virtually given by the Board on the resuscitation of this Company—that its resuscitation was necessary in order to obtain a dividend for the first preference shareholders. During the nine years the Company was in existence preceding its restoration the total amount paid in dividends was £21.875, and that was only paid during the two last years of the existence of the Company, and with the present directors in office. As compared with this, the present Board, during the two years of the existence of the reconstituted company had distributed in dividends no less than £60,326, and placed to reserve the sum of £13,000. If these results did not entitle the directors to the confidence of the shareholder, he did not know what results would, and he also ventured to say that they altogether dissipated the suggestion of negligence. As to the future, the Board who endeavoured to give a bloom to their report by holding out expectations, failed in their duty to the shareholders. The duty of a Board was to place before the shareholders the facts, and leave them to draw their own conclusions; and there was no material fact as to the future, which had not from time to time been fairly stated by the directors in their report.

The motion for the re-election of Mr. Ford was then passed unanimously, as was also the resolution for the re-appointment of Mr. J. G. Griffiths, the auditor.

A vote of thanks to the Chairman and directors then terminated the proceedings.

THE GERMAN UNION TELEGRAPH AND TRUST COMPANY (LIMITED).

The eighth ordinary general meeting of the shareholders of this Company was held on Saturday, May 10, at the offices, 66, Old Broad-street, under the presidency of Sir James Anderson.—Mr. William Payton, the secretary, having read the advertisement convening the meeting, the minutes of the last general meeting were confirmed. The report of the directors, which was taken as read, stated that the total receipts during the year (which showed an increase over the corresponding period of last year of £63 3s. 9d.), amounted to £12,296 11s. 3d., which, with a balance of £109 10s. 6d. carried forward from last account, made a total of £12,406 1s. 9d. The working expenses for the same period amounted to £455 17s. 4d., leaving a balance available for dividend of £11,950 4s. 5d. The Company's cable and land lines were in good order and condition, and had continued to work satisfactorily throughout the year. This fact was confirmed by the constantly increasing use made of the lines by the Government Telegraph Administrations for the transmission of messages passing between the Continent of Europe and the United Kingdom. The duplex system had been successfully applied to the Company's cables since the 1st July, 1878. A question of the greatest importance to the financial interests of the Company, which had been in course of discussion since the year 1876, was settled towards the end of last year. The word system of charging commenced on the 1st of January last, and an agreement was entered into between the parties concerned, in which the interests of this Company were fairly and reasonably considered and provided for by the Government Administrations, and the directors believed that, with a reasonable increase of traffic, the receipts of the Company would not suffer by the introduction of the new system.—The Chairman said that he had to move in the usual way the adoption of the report, "That the report and accounts of the directors for the year ending May 1, 1879, submitted to this meeting, be and they are hereby received and adopted, and that a dividend be now declared of 6s. 3d. per share, making with an interim dividend of 5s. 9d. per share paid on the 21st January last, a total distribution of 12s. per share, free of income-tax, or at the rate of 6 per cent. per annum." There was, he observed, very little to say about the report. It was very short and concise, and two or three points in it would, consequently, be enough to refer to—that they paid 6 per cent., that their cable was in good working order, and that they had adopted the word system and the duplex, both of which were more likely to develop telegraphy between such important centres as London and Germany then perhaps anything else. They had every reason to believe that the word system would be adopted throughout the whole of Europe at the Congress to be held next month. The main point of all in the accounts—to his mind, at all events—was the fact that they were laying by a very fair reserve fund—about £2,000 a year. The accounts of what they called the "parent" Company showed that they had put by about £14,000 for repairs and renewals. He regarded that as a very fortunate circumstance, and a feature of this Company, because it gave them, at all events, a secure property, which was of more consequence in a telegraph company than anything else—more than large dividends. He would rather, for his part, in every company he was in, pay no more than 5 per cent. till they had enough laid by to replace the property if required; and that they were going on steadily in that direction was to him very gratifying, and was the main feature of the report—worth almost all the rest of it. He concluded by moving the resolution.—Mr. Henry Weaver seconded the motion, which was carried unanimously.—On the motion of Mr. Weaver,

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seconded by Mr. H. G. Erichsen, Sir James Anderson was re-elected to hi seat at the board; and subsequently, on the motion of Mr. Alexander Beattie, seconded by Mr. Drage, Mr. Henry Dever was re-elected auditor to the Company for the current year at a remuneration of £25.—Mr. Beattie then observed that he regarded the reserve fund as a most important feature of their concern, and he felt that every word of the chairman was true, except that he did not quite feel sure that all the money should be got out of the present shareholders, who had had to bear the heat and burden of the day. Of course, he quite agreed that they should provide a great portion. He should also like to know what was the progress of the reserve fund.—The Chairman, in reply, said about 20 per cent., or £2,000 a year, was put by. He would not say that they should lay by sufficient reserve to replace the whole capital. There were two or three things to bear in mind. They could now lay a cable cheaper than the existing one, and he took it that three times the money now in hand would provide a cable with a single wire. He should regard that a good security—three times the present reserve, so that they would never quite lose their communication, but he would still go on increasing until they could renew the whole system. —Mr. Beattie observed that he had merely desired to moderate the chairman's view a little, on which Sir James Anderson remarked that Mr. Beattie might feel assured he would not be allowed to have his way altogether.—On the motion of Mr. Beattie, a vote of thanks was passed to the chairman and the directors for the care they had taken of the shareholders interests, and the chairman having expressed the thanks of himself and his colleagues, the meeting separated.

WOMEN IN THE TELEGRAPH SERVICE.

Will you (says a correspondent to the *Daily News*) allow me through your columns to direct the attention of the public to a matter in which, I venture to think, they are not a little interested? At the present time large numbers of young women of the middle classes, whom circumstances have driven or led to seek remunerative employment, find it in the Government Telegraph Department. With this the general public are, I believe, quite satisfied. They are of opinion that the large and increasing class of women who must be self-supporting are thus afforded a mode of self-help which befits them, and for which they are well fitted. The Government appear to think otherwise. During the last two years no female clerks have been taken on in the Telegraph Department, and the female branch of the Government Telegraph School is closed. Those women who are already employed in the department have not, it is true, been dismissed; but, as the places of those who leave are not filled up, those who remain are subjected to an ever-increasing amount of work, and their position is constantly growing worse. Is this with a view to producing breaks-down which may be adduced as a proof that women are incapable of this class of work? Female clerks are supposed to work eight hours a day. As a matter of fact those employed at the Central Telegraph Station are called upon to work ten hours a day, and six hours a day in alternate weeks, being further liable in the six-hour week to overtime if required. There is no break in the work-time except half an hour for dinner. The Factories Act, 1874, says that no woman shall be employed continuously for more than four hours and a half. Is it a fair test that the strain of the ten-hour week, now that the staff is so reduced that each must do more than the work of one, tells sorely on many girls, and forces some to leave? In a word, I ask the public whether they do not think that a twofold, and not very straightforward, process of excluding and expelling women from a field of work hitherto open to them is being carried on, and whether it is their wish that this process should be continued and consummated?

Killed by Lightning.—Birmingham was visited on Wednesday by a series of thunderstorms. In the morning, when the storm raged with great severity, five carmen in the employment of a local building contractor left their waggons and sought refuge in a little hut on the Chester-street Coal Wharf. They had scarcely entered the hut when a vivid flash of lightning caused some of the horses to start, and, fortunately for themselves, two of the men ran out to restrain the animals. Immediately afterwards another and more vivid flash, which appeared to envelope the hut, passed through the window, and struck the three men who were sheltering inside. Two of them, named Harvey and Steedman, were killed on the spot. The third, named Williams, was thrown to the ground, and was badly injured in his leg. Strange to say, with the exception of the breaking of some panes of glass in the window, no damage was done to the hut. Harvey, who was in the prime of life, was married. Steedman was a lad of 18.

A Shilling Electric Lamp.—Electrical science provides an almost inexhaustible store of experimental work for our "boys and girls." They will be gratified to know that the Scientific Toy Company has provided a lamp which will actually burn, and which will therefore enable them to carry out their simple experiments with the electric light. The lamp is really a cheap form of the Harrison lamp or an inverted Werdermann. A large piece of carbon forms the base, on which rests a small carbon rod. The incandescence of the latter gives the light. Four Bunsen or Groves cells are required, and the carbon supplied is sufficient to last two hours. Surely our little friends will be thankful to be able to get such a cheap piece of apparatus.

TRAFFIC RECEIPTS FOR APRIL, 1879.

Companies.	April 1879.	April 1878.	Increse.	Decrse
Anglo-American Telegraph Company	45,540 estd.	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,000 estd.	2,940	60	—
Direct Spanish Telegraph Company	803	746	57	—
Direct United States Telegraph Company	15,790	—	—	—
Eastern Extension Telegraph Company	21,060	21,753	—	693
Eastern Telegraph Company	37,846	32,210	5,636	—
Great Northern Telegraph Company	16,299	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—
West India and Panama Telegraph Company	—	—	—	—

RECENT PATENTS.

3333. Obtaining and Applying Motive Power by Magnets, *J. E. F. Lüdeke and A. J. Thorman.—Dated 24th August*, 1878. 6*d*.

A bar of soft iron is balanced on a centre so as to move with the greatest freedom. At two points of the circle this bar would describe are two horseshoe magnets, placed opposite to one another, so that the north poles of the one are opposite to the south poles of the other. At the inner sides of the poles of the magnets are stops of brass for preventing the bar, though alternately attracted by the poles, from coming into actual contact with them. Over the middle of the bar is placed another horseshoe magnet, attached to a pendulum made to oscillate, so that the north and south poles are alternately over the middle of the bar. The effect of this is, that the ends of the bar are attracted by one pole and repulsed by the other, the contact being broken and given at one and the same time, the current of the poles being reversed. A crank is attached to the bar for transferring power or motion, and is connected to the suspended magnet, that the same may oscillate as required.

3367. Galvanic Batteries, *J. C. Fuller and F. H. W. Higgins.—Dated 26th August*, 1878.—(*Not proceeded with.*) 2*d*.

An amalgamated surface is substituted for the zinc or positive plate of a battery.

4466. Improvements in Distributing Electricity for the Production of Electric Lights.—*Dated November* 5, 1878.

The object of this invention is to enable the electricity generated by a dynamo-electric machine (or obtained from any other source) to be distributed through a number of circuits in succession in such a way as to permit of one, or as great a number of electric lights as may be required or found practicable, being established and maintained in each circuit by means of electric lamps. In carrying out this invention, for lighting a town there would be a number of Gramme or other dynamo-electric machines or other apparatus for generating the electric current or currents at a central station, and separate main wires or cables of wires would be led from these electric machines to a number of district stations, one to each; or the Gramme machines might each be located at its corresponding district station if preferred. At each district station there would be a switch or commutator, worked by any suitable motor, for distributing the flow of the electric current to the different branch wires or circuits on which the electric lights are to be established as hereinafter described. This switch or commutator is kept in motion at a constant speed for putting all the branch wires in connection with the main circuit at regular and rapidly recurring periods of time. It comprises a rapidly rotating arm, terminating in a spring contact, which passes over and presses lightly upon a number of metallic contact pieces or pins, insulated from each other, and distributed at equal intervals around the face of a disc, and equal in number to the number of branch circuits in which the lights are to be produced in the district. The main wire or cable from the Gramme or other machine at the central station is in electrical connection with the arm of the commutator through its axis. Now, as a luminous object remains for about one eighth of a second upon the retina of the eye, it is evident that any object which is seen more than eight times in a second will appear to be constantly visible. If, therefore, the commutator arm rotates, say, sixty or more times in a second, a current of electricity will be sent through each of the branch wires sixty or more times in a second, and if one or more suitable arrangements of carbons or other appliances for establishing the electric light be interposed in the circuit of each branch wire, the several lights will appear to be constant, notwithstanding that the flow of the current is intermittent, it being, in fact, interrupted at the rate of sixty or more times in a second. The electric light or lights on any one or more of the branch circuits may be dispensed with by breaking those circuits without in any way interfering with the others, or necessitating any alteration in the working of the commutator.

TELEGRAPH SHARE LIST.

Companies.	Closing Prices May 14.		Business Done Week Ending May 14. Highest.	Lowest.
Anglo-American	55¼,	6¼	56	55¼
Do. "B"	85½,	6¼	86	85
Do. "A"	27½,	8	28	27
Brazilian	6¼,	¼	6¼	6 13-16
Cuba	8,	¼	—	—
Do. Ten per Cent. Preference	15½,	16½	16	16
Direct Spanish	1½,	2½	—	—
Do. Ten per Cent. Preference	10½,	11	10¾	10½
Direct United States	10½,	11	11	10½
Eastern	7¼,	¼	7 13-16	7¼
Do. Six per Cent. Debenture	104,	7	107¾	107¼
Do. Five per Cent. do.	102,	4	103	103
Do. Six per Cent. Preference	11¼,	12	12	11¼
Eastern Extension	7¼,	¼	7¼	7 9-16
Do. Six per Cent. Debenture	108,	110	110	110
German Union	7¼,	8½	—	—
Globe Telegraph and Trust	4½,	5	5	4¾
Do. Six per Cent. Preference	10 15-16,	11 1-16	11	10¾
Great Northern	8¼,	¼	8 7-16	8 5-16
Indo-European	20½,	1½	20½	20½
Mediterranean Extension	2½,	3	2¾	2¾
Do. Eight per Cent. Preference	9¼,	¼	9¼	9¼
Reuter's	9¼,	10½	—	—
Submarine	220,	30	—	—
West India and Panama	1¾,	¼	1 9-16	1¾
Do. Six per Cent. Preference	8¾,	¼	8¾	8¾
Western and Brazilian	3¼,	¼	3¼	3¼
West. Union Seven per Ct. 1st Mt.	111,	114	—	—
Do. Six per Cent. Sterling	102,	4	—	—

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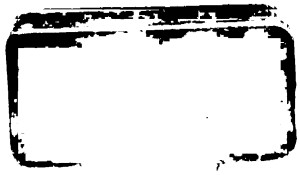

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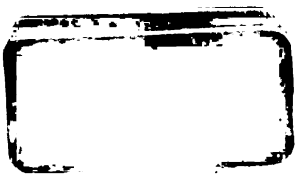

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